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SYNOPSIS OF RECENT PROGRESS IN THE STUDY OF GRAPTOLITES.

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THE graptolites have been a puzzling group of fossils to palæontologists ever since they were discovered. Though on account of their excessive abundance in certain strata, the beauty and variety of their delicate forms, and the strange mode of their vertical and horizontal distribution they have always received a full share of attention, the knowledge of their morphology has made only little progress, owing to their preservation as completely flattened carbonaceous films. As a result of this incomplete knowledge of their structure, the systematic conscience of palæontologists acquiesced in their being assigned to the Hydrozoa, in spite of the difficulty arising from the formerly commonly accepted presence of the virgula or "solid rod" in the rhabdosome and the supposed floating habit of the graptolites. The fact that they were found to furnish excellent data for the detailed division into zones of the Cambrian, Ordovician, and Silurian strata prevented their neglect, although so refractory to all attempts at close morphologic investigation, and the search for them in the field never relaxed. The grati-

fying result of this persistency is that at last material has been found which is accessible to modern refined preparative methods and to microscopic analysis.

Gümbel ('78) was the first to isolate stipes imbedded in limestone. Later Törnquist ('90, '92) obtained much valuable information by grinding pyritized material. The best results, however, have been obtained by the methods employed lately by Holm ('90, '95) and Wiman ('93, '95). For the details of these preparative methods, the reader is referred to Wiman's interesting account in his paper, "Ueber die Graptoliten" ('95), the review ('96) of his work in the *American Geologist*, and to Wiman's "Structure of the Graptolites" ('96).

Both Holm and Wiman isolated stipes by dissolving the matrix. Various acids have been used for dissolving, according to the nature of the rock. Limestone material was found the simplest to handle, and muriatic acid in different states of solution or milder solvents, such as acetic acid, gave good results. Especially interesting to American readers is the description which Wiman gives of his treatment of highly aluminous clay slates, as these are almost the only graptolite-bearing rocks found here. Wiman subjected them to the successive action of acetic and hydrofluoric acids. J. M. Clarke handled similar material successfully with acids and caustic potash. These methods, however, fail with a matrix that does not contain a sufficient lime-content to lose its consistence by the dissolution of the latter, and this appears to be the case with most of the American graptolite-bearing rocks. Wiman had also occasion to isolate graptolites from chert-masses by successively subjecting the rock to a treatment with concentrated hydrofluoric acid and muriatic acid.

The isolated graptolites have been decolored both by Holm and Wiman in different ways. Wiman used first Schultze's maceration medium, which is a solution of calcium chlorate in nitric acid, but later substituted for it eau de Javelle or potassium hypochlorite, because Schultze's medium is often too harsh. The specimens were then cleared with chloroform or other clearing fluids and mounted in Canada balsam, or, where this method could not be used on account of the thickness of

the periderm, the specimens were prepared for the microtome according to the methods used by zoologists.

By the application of these preparative methods histological and morphological discoveries have been made.

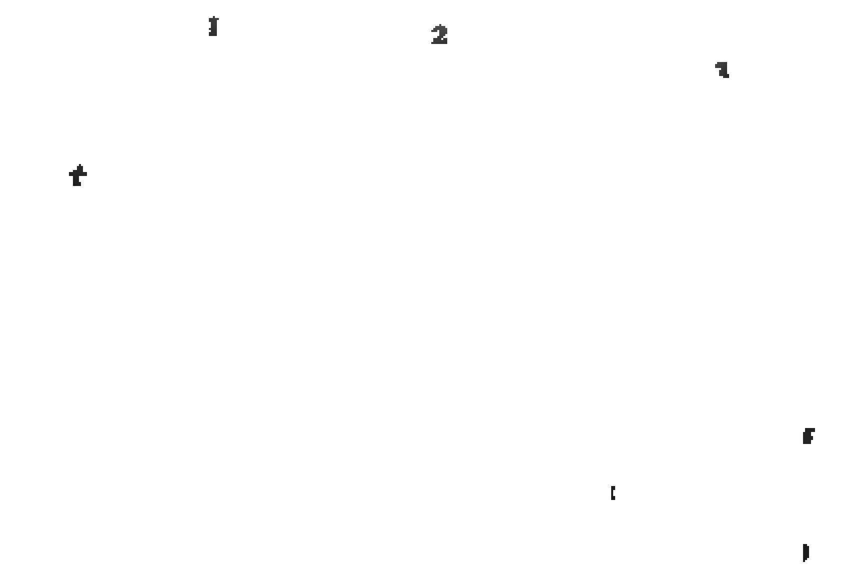
The histology of the graptolites has been especially advanced by the researches of Holm ('90), Sollas ('94), and Perner ('94). The last two investigators demonstrated the presence of three different layers in the periderm of Monograptus; *viz.*, a stronger middle layer between two thinner ones. Wiman ('95) verified Perner's observations as to *Monograptus priodon* and discerned the two outer layers in Diplograptus. The middle layer in Diplograptus contains the growth-lines observed repeatedly before. The histology of the Retioloidea has been studied by the above-named geologists and by Tullberg ('82) and Törnquist ('90, '93). Holm found three layers; *viz.*, smooth epidermic and endermic layers, which inclose the latticed network of chitinous threads, from which this group derives its name.

In the Dendroidea Wiman ('95) observed the two outer layers.

However interesting the discovery of the differentiation of the periderm of the graptolites is, especially on account of its bearing on the question as to the zoological affinities of this group, it is surpassed in importance by the knowledge which has been obtained as to the morphology and development of the graptolites. In reviewing the progress made in these directions we will separately regard the Graptoloidea, Retioloidea, and Dendroidea.

As an understanding of the conformation of the rhabdosome rests with the knowledge of its growth from the sicula, it will be opportune to review first the fundamental results obtained by Wiman as to the growth of the initial part of the rhabdosomes of Monograptus ('93), Diplograptus ('93), and some other Graptoloidea. The sicula of these consists of a thin-walled "initial part," which is prolonged into a process, the "virgula," and of the "apertural part," which shows distinct growth-lines and a three-spined symmetrical aperture (Fig. 1, *s*). From the sicula sprouts a new individual, the first theca (Holm considers the apertural part of the sicula already as "first theca"), which

in Monograptus lies alongside the sicula and grows at once in an opposite direction (Fig. 1, *t*). From this theca grows another. The continuation of this process and the arranging of the thecæ in one series along the virgula produces the monoprionidian rhabdosome of Monograptus. Also from the sicula of Diplograptus, as Törnquist ('93) and Wiman found almost simultaneously, there sprouts but one bud, and Diplograptus is, therefore, also monoprionidian. The first theca, however, grows at first towards the aperture of the sicula and then bends in the same



In Figs. 1–8, s = initial part of sicula; s_1 = apertural part of sicula; v = virgula; t = theca.

FIG. 1. — *Monograptus dubius* Suess: sicula end from sicula side (Wiman).
FIG. 2. — *Diplograptus sp.*: sicula end from sicula side (Wiman).
FIG. 3. — The same: a later stage from anti-sicula side (Wiman).
FIG. 4. — *Climacograptus kuckersianus* Holm sicula side (Wiman).

direction as the thecæ in Monograptus (Figs. 2, 3). The thecæ are arranged in two series, thus producing the diprionidian aspect. The supposition that the diprionidian graptolites consist of two coalescing monoprionidian branches, the double virgula and the double longitudinal septum of the older descriptions, has thus been refuted; the observations of Tullberg, Törnquist, and Wiman prove that not even a single longitudinal septum is always present, and that, if one is present, it does not necessarily extend throughout the entire length of the rhabdosome. Fig. 4, representing a rhabdosome of Climacograptus,

demonstrates that a septum is formed, where the thecæ, instead of sprouting on the opposite side of the adjacent older thecæ (t_1 t_2), spring from the same side as the latter did (t_4 t_5).

Holm ('95) obtained most valuable information on the internal structure and development of some other important genera of the Graptoloidea; *viz.*, of Didymograptus, Tetragraptus, and Phyllograptus. The most interesting result of his researches is the demonstration of the conformity in the first stages of development of the rhabdosomes in these genera and the Diplograptidæ. It is probable, therefore, that the earlier develop-

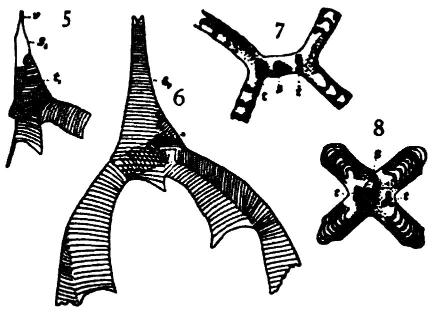


FIG. 5. — *Dichograptid*: anti-sicula side (Wiman).
FIG. 6. — *Didymograptus minutus* Törnquist: anti-sicula side (Holm).
FIG. 7. — *Tetragraptus Bigsbyi* Hall: from the proximal end, with the sicula turned upwards, showing the aperture of the sicula, left and right thecæ, and the thecæ of the four branches (Holm).
FIG. 8. — *Phyllograptus angustifolius* Hall: from the proximal end, with the sicula side turned upwards, showing in the middle the aperture and the oblique position of the sicula, on each side of this the apertures of the left and right thecæ (Holm).

ment of all Graptoloidea was the same, and that it consisted in the formation of only one bud on one side of the sicula.

Fig. 5 (from Wiman, '95) shows the initial part of a Dichograptid, and Fig. 6 (from Holm) of *Didymograptus minutus*. Both figures serve to illustrate the diverging growth of the first two thecæ, which produces the characteristic bifurcation of these forms. The repetition of this process (Fig. 7) in Tetragraptus leads to the formation of four branches. The same takes place in the development of Phyllograptus (Fig. 8), "only that the four branches are disposed near each other and form a single, cruciform, four-winged, longitudinal septum."

The conformity of the rhabdosomes of all Graptoloidea has been made probable by these investigations (the Leptograp-

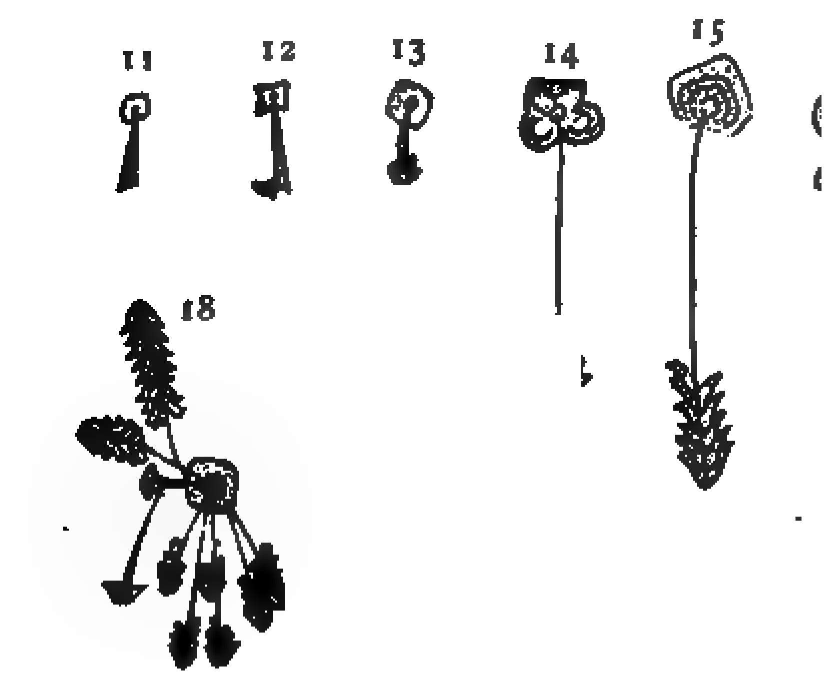
tidæ and Dicranograptidæ have not yet been isolated). The morphology of the entire colonial stock, however, is, owing to the frequent occurrence of only detached rhabdosomes, still little known. Hall ('65) first described stellate groups of Dichograptidæ from Canada; Hermann ('85) such from Scandinavian rocks; Moberg ('93) published a description of a Monograptus with disk; and Gurley ('96) figured a Climacograptus with a disk-like expansion of the virgula. Ruedemann ('95, '97) discovered colonies of two species of Diplograptus in Utica shale which have been deposited under such conditions of quietude as to retain not only all the chitinous appendages of the mature colonies, but also the successive growth-stages of the compound colonies.

It appears from the material that the rhabdosomes of Diplograptus formed umbrella-shaped colonies, consisting of rhabdosomes of various length, which radiate from a central organ,

FIG. 9.—*Diplograptus foliaceus* Murch (*D. pristis* Hall): complete colony (Ruedemann).
FIG. 10.—The same: *a*, Gonangium filled with siculæ; *b*, sicula developing into a stipe (Ruedemann).

the central disk (Fig. 9). The latter, in its turn, is connected with a larger organ, the basal cyst, that probably served to secure the stability of the colony in the ooze of its habitat. The central disk is surrounded by a cycle of vesicles which

contain numerous siculæ attached by their apical ends (Fig. 10). The writer compared these vesicles with the gonangia of the sertularians, considering the siculæ as the original chitinous



FIGS. 11–20. — The same: development of a colony (Ruedemann)

coverings of the embryos. (Holm sees in the initial part of the siculæ the covering of the zooid germ.) The development of the colony is as follows:

1. The sicula is provided with a basal appendage to which it is attached by means of a little round node (Fig. 11).

2. The node becomes a central disk and funicle. The sicula produces at first one theca, then a second, a third, etc., as demonstrated also by Törnquist and Wiman (Figs. 12, 13).

3. The budding of the thecæ along the lengthening hydrocaulus produces the primary rhabdosomes (Figs. 14, 15).

4. While the latter is formed, gonangia, usually as four small capsules, arise from the central disk. At last the latter mature and open. Many, or perhaps all, of the siculæ remain connected to the parent colony (Figs. 16, 17).

5. These siculæ grow out to rhabdosomes (Fig. 18).

6. After this first generation of rhabdosomes has reached a certain age a second generation of gonangia begins to grow (Fig. 19).

7. The siculæ formed in these develop into a new verticil of rhabdosomes.

The result of this mode of development is a colony which consists of different generations of rhabdosomes, recognizable by the different lengths of the latter (Fig. 20). An especially remarkable feature of the colonies is the position of the sicula at the distal end of the rhabdosome in regard to the central disk. The explanation of this peculiar position of the sicula is found in the observation that the first theca turns away from the aperture of the sicula and grows towards the apical part of the latter, or towards the central disk, thus forcing the whole rhabdosome to grow backward, so to say, towards the center of the colony. Wiman's figure of the initial part of the rhabdosome of Climacograptus and Gurley's figure of a colony indicate a mode of growth similar to the one described, only that in Climacograptus the colony apparently consisted of only one (the primary?) rhabdosome, as perhaps all siculæ became detached and developed colonies of their own. Also in Monograptus the same mode of growth prevailed. In Phyllograptus the rhabdosome grows also in an opposite direction to the sicula, but no virgula has been found by Holm, and the mode of fixation of the rhabdosome is still doubtful.

In the other genera of the Graptoloidea, however, it has been found that the first theca grows more or less in the direction of the sicula. As a result, the sicula remains near the central disk, at the proximal end of the rhabdosome, and the latter grows distally. In the Dichograptidæ the whole colony is formed by dichotomous branching from one sicula, which remains at the center of the colony.

With the two different directions of growth of the rhabdosomes from the siculæ the presence of a virgula as rod in the rhabdosome is closely connected; for, by the observations of Tullberg, Törnquist, and Holm, the fact has been established that only the Graptoloidea with inward-growing rhabdosomes (Diplograptidæ, Monograptus) have virgulæ, while the others

have none. The explanation of this is found in the observation that the initial part of the sicula of probably all Graptoloidea is prolonged into a process (the virgula of Wiman, the hydrocaulus of Ruedemann, the nema of Lapworth), and that this process in the inward-growing rhabdosomes becomes incorporated as virgula, while in the outward-growing rhabdosomes it remains outside (the nemacaulus of Lapworth). The virgula was originally hollow. This is indicated by Wiman's observations in Monograptus and by the growth of gonangia from the central disk in Diplograptus, which gives the hydrocaulus the character of a stolon.

The demonstration that the virgula or "solid axis" of the older authors is present only in a very restricted number of Graptoloidea is of great interest, as the presence of this organ has been considered as one of the principal characters of the graptolites and has even procured them the name "Rhabdophora." The virgula, as identical with the hydrocaulus or nema of the sicula, is, in reality, present in probably all graptolites, for long filiform processes of the sicula have been observed in numerous genera (*e.g.*, Mæandrograptus, Didymograptus, Tetragraptus). Lapworth concludes from the presence of this process that all rhabdosomes were either fastened to a central disk, as in the Dichograptidæ and Diplograptidæ, or directly by the nema to foreign bodies.

We cannot leave the Graptoloidea without mentioning the important investigations of Tullberg ('82), Jækel ('90), Perner ('94), and Gürich ('93, '96) on the shape and position of the thecæ, and their apertures in Monograptus, which led to the division of the genus into the two subgenera Pomatograptus Jækel (*Monograpti reversi* Gürich) and Pristiograptus Jækel (*Monograpti erecti*), the interesting study of the phylogeny of the Dichograptidæ by Nicholson and Marr ('95), based on the shape of the thecæ, and the work of Miss G. L. Elles ('97) on the relations of the subgenera Petalograptus and Cephalograptus.

The knowledge of the structure and development of the rhabdosomes of the Retioloidea is still so uncertain that it can be passed here with the remark that a different number of

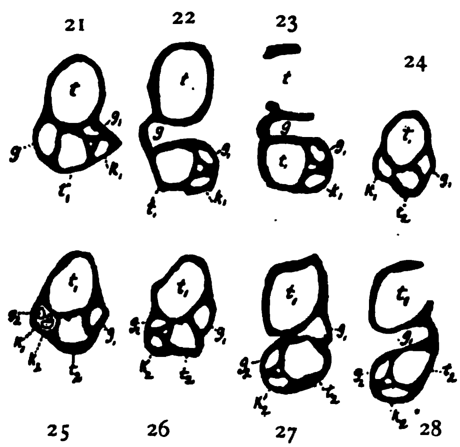
so-called virgulæ and an "initial canal" of the rhabdosome have been observed.

The most interesting discoveries have apparently been made in regard to the third group of graptolites, the Dendroidea. These finely branching, plant-like graptolites, on account of the absence of a virgula and the occasional presence of a distinct organ of fixation, which indicated a sessile mode of life, in opposition to the generally supposed floating habit of the Graptoloidea and Dendroidea, have been mostly separated from the other graptolites, and are often unhesitatingly united with the campanularians (*cf.* Zittel, '79). Their occurrence only as flattened films prevented, until recently, all attempts at closer investigations. The first indication of a more complicate structure was given by Holm ('90) in his description of *Dictyonema cervicorne.* He found that the branches of the rhabdosome in this species consist of vertical rows of thecæ, which end in hayfork-like spines. Situated alternately on two sides of these spines are peculiar cup-shaped bodies ("by-thecæ"), which he compares to birds' nests and supposes to have been gonangia. While Holm first isolated these delicate fossils from the limestone matrix, Wiman ('95, '96) went further, applied the microtome to them, and obtained a complete series of thin sections of Dictyonema, Dendrograptus (?), and Ptilograptus. The important result of his microscopic analysis is the discovery that the morphological structure of the Dendroidea is much more complex than was suspected, and that there are not less than three different forms of thecæ, *viz.*, thecæ proper, or nourishing individuals, alternating canals (Holm's by-thecæ), which Wiman also considers as gonangia, and gemmating individuals. The following illustrations (Figs. 21–28), selected from a series of one hundred and twenty-five sections through a branch of *Dictyonema rarum* Wiman, show this diversity of the thecæ quite plainly. The nourishing individuals are denoted by *t*, the gonangia by *g*, and the budding individuals by *k*. Fig. 22 shows the opening of the gonangium on the right side; Fig. 23, the ceasing of the theca; Fig. 24, the growth of a new theca. In section 25 the budding individual has produced three new individuals, the further growth of

which is shown in section 26, while in section 28 the opening of the next gonangium can be seen.

The hayfork-like outgrowths of the thecæ observed by Holm and Wiman are supposed by the latter to have aided in the process of propagation. In the writer's opinion, they also remind one of the nematocalyces of certain Plumularidæ, which are similar processes provided with a nematophore or altered individual for the purpose of seizing food. They would then constitute a fourth kind of individual.

While it becomes apparent from these discoveries that the three groups of graptolites are more different than had been



FIGS. 21–28. — *Dictyonema rarum* Wiman: series of transverse sections (Wiman).

supposed, it yet seems allowable to retain them in one class. The systematic position of this class seems, by the observed complex structure of the periderm and the high organization of the rhabdosome in general, to have become more uncertain than ever before. As we saw before, the grapolites have, for a long time, quite generally been united with the campanularians. Lately, objections against this union have been raised, especially by Jækel and Neumayr ('89). Wiman holds the same view as Neumayr, namely, that the graptolites cannot be placed in any of the groups of living animals, while Ruedemann sees in the gonangia of Diplograptus a new indication of relationship with the Sertularidæ. Whatever the relations of the grapto-

lites may be, it certainly is necessary for the understanding of the life history of the individuals of the colonies to compare the graptolites with some class of living animals, and there is undoubtedly no other class available but the order of Campanulariæ. It also should not be forgotten that the virgula, which always has been considered as constituting one of the principal differences between graptolites and campanularians, has been proved to be comparable to the hydrocaulus of the first theca of the Campanulariæ.

Another difference between graptolites and campanularians has been supposed to consist in the floating habit of the former. This leads us to the interesting question as to the mode of life of the graptolites, which lately has been discussed by an author (Lapworth, '97) whose lifelong study of these fossils, both in the laboratory and in the field, gives his views the greatest moment.

The peculiar mode of occurrence of the graptolites, *viz.*, in numberless multitudes of broken rhabdosomes in highly bituminous shales, which are otherwise poor in fossils, their astonishingly wide horizontal distribution and limited vertical range, has often been an object of speculation. But it is now to be hoped that, by the light shed lately on the structure and development of the colonies, by the exhaustive study of their distribution, and especially also by the researches which recently have been carried on so extensively in regard to the conditions and distribution of life in the ocean, the clue to the understanding of their mode of occurrence will be found. The works of Walther ('93) and Ortmann ('96) have done much to make the results of these bionomic researches known among geologists, and Walther's investigation has given the direct instigation to Lapworth's valuable discussion.

The common consensus of two generations of geologists, says Gurley, has been that the true graptolites (Graptoloidea, Retioloidea) were "floating." Jækel and Wiman, on the other hand, concluded from the heavy chitinous covering of the thecæ and the presence of the virgula as a supporting rod that the rhabdosomes were not suspended, but that the colonies were lightly moored to the ground. Ruedemann ('97) was forced to

believe in the sessile mode of life of at least one species of Diplograptus by the finding of a slab (*cf. op. cit.*, Pl. V) which showed a great number of well-preserved colonies spread out regularly in about equal distances from each other and arranged in a well-defined area. Gürich ('96) and Lapworth ('97) have advanced ideas lately as to the mode of life of the graptolites which correspond to each other, and which apparently explain many of the peculiar features in the distribution of these fossils.

Lapworth found in Great Britain that graptolites may occur in all sediments, but that they are found only in great numbers in rocks containing a considerable amount of carbonaceous matter, and that the frequence of the graptolites is directly proportional to the amount of bitumen present and to the fineness of grain in the matrix. As the least motion in the water would carry away the light carbonaceous matter, Lapworth concludes further that the relative frequency of graptolites in a sediment depends also on the quietude of the water in which the rock was formed. This view is especially interesting to the writer in reference to his observation of a parallel arrangement of the rhabdosomes of graptolites in the Utica shale of the Mohawk Valley ('97). This arrangement indicates the passing, during the Utica epoch, of a constant current in a northeast to southwest direction along the southern coast of the Adirondack crystalline area. As the alternation of graptolite-bearing shale and coral-line limestone in the lower part of the Utica shale proves, the current must have been strong enough to bring in the fine mud forming the shale, but cannot have been strong enough in the greater depths, where the deposition took place, to drag the well-preserved, delicate rhabdosomes for a long distance. The occurrence of numerous perfect colonies in two localities is proof of the occasional presence of almost perfect quietude. The latter, however, was the rare exception, the rule having been a slight motion, the traces of which can be found throughout the whole system of shales. The fine sinking mud undoubtedly assisted greatly in keeping the carbonaceous matter at the bottom.

Lapworth further opposes the opinion, so often advanced, that the graptolites furnished the carbonaceous matter in the

matrix on the grounds that they are rarely found in a partly decomposed state. From the appearance of the colonies and their fragments, it is concluded that they sank slowly through quiet water to the bottom. As the carbonaceous matter in the rocks is a steady companion of the graptolites, it is supposed to have sunk together with the latter. The source of this carbonaceous matter is found by Lapworth in seaweeds, which, like the living sargassum, were pseudo-planktonic; that is, were originally sessile, but, being torn off, continued to live and were carried by the currents into all seas. Just as the richest fauna of campanularians is still to-day found on the floating seaweeds of the Gulf Stream, so the graptolites are supposed to have flourished on the floating masses of palæozoic algæ. To strengthen this theory, Lapworth calls attention to the fact that it has been found that the rhabdosomes are either fastened to a central disk or have at least a nema. Both central disk and nema indicate that the graptolites were sessile. The Dendroidea alone, which are never so common as the other graptolites, fastened themselves to rocks and stones, and belonged to the "benthos" (lived at the bottom). Originally, however, all graptolites were benthonic, and become only later pseudo-planktonic. This change in the habitat necessitated a change also in the direction of the thecæ, which is indicated in the course taken by the first theca of Diplograptus (Fig. 2), and by the direction of the thecæ of Monograptus and of the branches of Didymograptus, Tetragraptus, and Phyllograptus.

It cannot be denied that the peculiarities of the distribution of the graptolites and their structure are well explained by Gürich's and Lapworth's theories. It is highly probable that many graptolites were indeed pseudo-planktonic, while some may even have gone further and have become free-floating or planktonic, and others are known to have been sessile at the bottom.

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CONTRIBUTIONS ON THE LIFE HISTORIES OF CERTAIN SNAKES.

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IN reading over the magnificently compiled monograph of the poisonous snakes of North America by Mr. Leonhard Stejneger, and also an article on the breeding habits of snakes by Dr. O. P. Hay, in the *Proceedings of the U. S. National Museum* (Vol. 15, 1892), I find many points of character as well as of the reproduction which appear, according to both writers, very obscure.

My observations, extending over a period of nearly twenty years, were made principally on ophidians, occurring in central Europe, Central America, and our southern states, chiefly Louisiana, and were conducted both in nature as well as confinement, the latter especially with a view to note the extent of the exceedingly limited mental capacity and the development of their sense organs. I have noted the entire period of gestation of at least three of our venomous snakes from the time of sexual union to the end of the term, and I dare say with comparative certainty that the same length of gestation occurs as well in *Natrix rigida* and *Natrix grahamii*.

The term of gestation may vary to a limited number of days, but all my notes point to five months and a few days.

While searching for reptiles in the vicinity of New Orleans on the 10th of March, 1893, I happened to come across a pair of *Agkistrodon piscivorus* in coitu, which must have, evidently, been nearly or quite completed, for the male freed itself so quickly that I failed to secure it, but the female, an unusually large one, became my captive.

She proved to be a very aggressive and obstinate individual for quite a long time, and refused food persistently for fully two months. The cage in which I kept her was prepared with some imitation of natural surroundings, and after the expira-

tion of about two months the snake commenced to feed on mice, and before another month passed by she swallowed pieces of raw beef and fish with avidity. I continued to feed her at the point of a little stick fairly regularly every two or three days. About four months from the day I caught her I noticed an increase in her size, but, of course, I could hardly credit my surmise at first. On August 17, however, she produced nine young ones. She killed one by lying on it, but the other eight were lively, in markings the same as the mother, but more distinct, and the ground colors much more reddish and brighter. To test their poisonous qualities I permitted one of them to bite me on the following day, but outside of the peculiar penetrating sensation attendant upon all venomous snake bites, and not unlike a bee sting, I did not feel other results. The young snakes measured exactly six and three-eighths inches in length, and in their thickest diameter four-fifths of an inch. The mother and five of her babies are now in the collection of Tulane University, all having died the following winter.

The winter of 1893–94 proved quite severe up to the end of February, 1894, and reptiles did not appear until then; but when I came to Avery's Island, on the last day of March, Mr. E. McIlhenny had collected for me a number of snakes, among them a full-grown ground-rattler (*Sistrurus miliarius*).

As soon as I reached New Orleans again, a few days later, I prepared a suitable cage for that snake. The first mouse I offered was killed and swallowed with the greatest promptitude. The deportment of this little rattler was not at all vicious, and after a short while would pay but little attention to what was going on in and about the cage; she even showed no signs of irritability if I accidently touched her with my hand while removing her water pan or cleaning out the cage. But I never succeeded in getting her to eat anything except mice. Toward the middle of July I noticed a gradual increase in her size, especially in the posterior portions, and on August 12 she gave birth to six little ones. They were born during the night, and I found each one of them curled up in the manner of the old one in different places in the cage. The newcomers were

the exact counterpart of their mother in color and markings, the ground color, however, much lighter, and the head being much more obtuse. Their length was five and one-half inches by a trifle less than one-fourth of an inch.

According to the condition of the weather and temperature, it is hardly possible that the snakes left their winter quarters before the beginning of March; mating must have taken place soon after, and, supposing it to have occurred about the middle of March, it will then determine the term of gestation to five months, or possibly a trifle over.

While on Avery's Island I captured, on April 1, two large water-moccasins. I kept the pair isolated from other snakes, but exactly thirteen days (August 25) after the birth of the ground-rattlers I came also in possession of eight young water-moccasins.

The same conditions as to temperature and the appearance of the snakes after hibernation prevailed in this case, and we find the term again to be five months and possibly a few days more.

In regard to the quotation of the notes on the pairing, etc., of *Agkistrodon piscivorus*, as observed by Effeldt in the Berlin Zoological Garden,[1] the period of gestation is considerably over five months. The dates, however, appear to have been noted with accuracy, and the excess of days in the period, if compared with my own notes, may be due to the climatic conditions under which the occurrence took place; but the statement of the size of the young at birth, as well as the color and markings, I believe to be unquestionably wrong. Our largest Crotalidæ never bring forth young of the length of ten and two-fifth inches, much less a water-moccasin.

On April 12, 1895, a negro came to me with an ordinary bird trap-cage. In it he had two magnificent copperheads, which he said he had caught on the previous evening in a cane-brake in the act of copulation. I purchased them and devoted considerable time to their care. Both of them accepted food very readily, and after awhile became gentler and more tractable, a trait which seems to me very much pronounced in copperheads,

[1] *Report of U. S. National Museum*, 1893, pp. 409, 410.

as I have found repeatedly illustrated in a number of other individuals of that species. I did not notice anything unusual until late in the evening of September 16, when the female (the larger one of the two snakes) brought forth seven young. These again were marked and colored like the parents, only more brilliantly. I have certainly no reason to doubt the negro's statement, especially as a later dissection proved the other snake to have been a male. The term of gestation is in this case again five months and four days. On May 3 of the same year some students brought me three specimens of *Natrix grahamii*, which they had caught in our university grounds. Two of the snakes were females. In September five young were born alive, while a sixth one remained dead in the membranous eggshell, although it had been expelled from the parent's body. I noticed that the food yolk of these little creatures was much larger and remained attached to them longer than in the young of the poisonous snakes.

In regard to *Eutænia proxima* and *E. sirtalis*, I am confident that, while, of course, the species are ovoviviparous as well, the number of young at one time is rarely more than eight or nine. Twice I have had young ones of that species born in confinement, at one time only five, at another, eight. They were five and three-fourths inches in length, and fully three-sixteenths of an inch in thickness. As to the term of gestation I am not certain, but pairing occurs in March and April, for I have had repeated opportunities to observe it in our swamps and palmetto thickets.

The structure of the membranous eggshell of all ovoviviparous snakes seems to be alike; it is very thin and perfectly transparent, and causes no difficulty to the young snakes to rupture it. The egg tooth, however, I have been able to find only in the young of *Natrix grahamii*. The motion of rupturing the inclosing membrane I saw very nicely demonstrated by the young of *Agkistrodon piscivorus*. The vertex lies close to the side of the wet and slimy shell; the simple motion of drawing the tip end of the nose upward and backward suffices to make an opening large enough for the little creature to crawl forth. All snakes shed skin from three to ten days after

birth. The food yolk remains attached for some time after birth, and *is not entirely absorbed before.*

There is certainly a grave mistake in Dr. H. C. Bumpus' account of *Eutænia sirtalis* (quoted in the *Proceedings of the U. S. National Museum*, Vol. 15, p. 388), for the genus Eutænia, as stated before, is ovoviviparous, and the young are marked just like the old ones, only much more brilliantly. Dr. Bumpus must have found the eggs of *Bascanion constrictor.*

According to the just-stated observations, the term of gestation seems to me definitely defined. At the same time we must also give credit to other statements, and the question arises, Do snakes copulate twice a year? Observations made by me in Europe on *Pelias berus*, *Vipera redii*, *Tropidonotus natrix*, and *Coronella lævis* seem to contradict such an assumption. In all cases, with the exception of *Vipera redii*, I have seen copulation in captivity, and I found the desire for reproduction to manifest itself in April and May, the young of Pelias and Coronella to be born in August and September, but the eggs of Tropidonotus to be laid in June and July. I placed freshly laid eggs of *Tropidonotus natrix* and *T. persa* in dunghills, and twenty-three days later I obtained the young ones. It is remarkable to notice the tenacity and intent with which the males persist in following up the females during the time of sexual desire.

How much I was mistaken in rating the toxic qualities of very young venomous snakes is illustrated by the following history of the bite of a young *Sistrurus miliarius.* As stated before in this article, I tried the effects of the bite of a young water-moccasin and experienced no results worth while mentioning.

During the noonday hour of Aug. 20, 1894, exactly eight days after the birth of the young ground-rattlers, I picked one of them up, teased it a little, and presented the first joint of the little finger of my right hand for a bite. The little snake bit with a vengeance. The momentary sensation resembled the sting of a bee; at the same time a lightning-like pain seemed to shoot up to the shoulder. A few minutes later actual pain extended to the second joint; a slight discoloration

around the wound, which, by the way, was scarcely perceptible, set in, indicating the destruction of the capillary walls and consequent extravasation. Œdema also made its appearance, and in a short while both swelling and pain increased in violence, extending gradually to the wrist and forearm, causing a numb sensation in the elbow joint, which sensation, however, disappeared again as the pains became more severe, and extended further up toward the shoulder. In less than an hour I was hardly able to raise my arm. Up to two hours after the bite the symptoms seemed to be merely local, but after that time they became systemic. General oppression and a slight degree of subjective vertigo commenced to be noticeable, both sensations increasing and remaining until after nightfall, and by eight o'clock dyspnœa became very troublesome. This feeling lasted until half past eleven, when I went to bed. The pain, however, which in the meantime increased in violence and extent, caused me to pass a sleepless night. By daybreak the swelling had extended well down my right side and upwards, even involving the same side of my face. Neither dilatation nor contraction of the pupil was noticeable. The pectoral region was extremely painful, but no such symptoms appeared in the scapular. The little finger was swollen to double its size, and the wound appeared like two black dots. The whole hand, as well as part of the forearm, showed upon pressure an exaggerated degree of resilience and heat. The temperature rose to one hundred and three degrees during the night, but by ten o'clock the following morning had subsided to ninety-nine and three-fifths. From that time on reaction set in, the symptoms gradually subsided, but an uncomfortable feeling throughout the entire system remained up to a period of thirty-six hours. After three days swelling and inflammation had almost all disappeared. Pains upon pressure, however, were noticeable as yet in the entire area which had been involved, and the discoloration in the axilla was very marked. Suppuration did not take place anywhere. No remedy had been applied from beginning to end.

The development of the sense organs in snakes leaves one in doubt at times just how far it extends. Sight is fairly good as

long as the object is moving; but I hardly think there is enough comprehension to distinguish a rat or frog as long as they will keep perfectly still. I have noticed that a snake will follow its victim around and around with its eyes, but, even if it should stop suddenly right in front of the snake and in convenient distance to strike, and keep perfectly motionless, the snake appears to be in doubt of its identity; the slightest muscular twitching in the victim, however, is then of course sufficient to overcome the uncertainty and hesitancy of the snake.

Smell is imperfectly developed, but it is amply supplemented by their exquisite feeling in the ends of the tongue. The sensitiveness of that organ is so fine that an absolute touch does not seem to be necessary, but the impression is conveyed to quite a long distance, sometimes for an inch or two. In regard to hearing, it is rather difficult to obtain accurate knowledge. At times it appears very acute, and at others no attention whatsoever is paid to sounds. If snakes are very alert and some noise is made, without disturbing the cage in the least and without making oneself visible, I found that they would catch up the sound waves very readily, and conveyed the fact by turning their head quickly in the direction of the sound and by their rapid display of the tongue.

The most careful and thorough observations, however, have so far not brought me to the solution of that bugbear of herpetologists, the use of the pit of the Crotalidæ and their next of kin, the moccasins. The assumption of the existence of a sixth sense is certainly easily maintained by the anatomical structure of the pit and the ramifications of the nerve in its linings.

On the life of some of our venomous snakes in captivity a few remarks may not be out of place. It is generally believed that they refuse food persistently and finally die of starvation. I have found, however, that the majority will accept living food without hesitation, as long as their receptacle is in any way arranged like their native haunts. The most interesting of our venomous ophidians I consider the copperhead, which in captivity becomes very tame, learning to take food, such as pieces of meat and fish, from the fingers. I possessed one some time

ago which would drink water out of a small graduated glass while I held it in my fingers. This snake learned to know very well that when I opened its cage door something in the line of food or drink was forthcoming. Several other copperheads that I kept at different times became quickly tame, and I found them easily satisfied with pieces of fish, which they preferred to beef. Water-moccasins became very tame also, but they are much more sluggish, and therefore less interesting. Of the latter I kept one pair nearly seven years in the cage. I suppose I would have them still if some one had not killed them by throwing boiling water on them when I was taken ill.

The greatest enemy of snakes kept in captivity I found to be a flat worm, shaped and colored almost like a leech, which penetrates all tissues. I found them at one time in the pericardium of a rattlesnake. Once these parasites manifest themselves, it is generally the death warrant to all snakes kept in confinement at the time. Another very troublesome and usually fatal affection appears in the shape of brownish-looking pustules; they are malignant, and the only chance in keeping the other snakes is isolation of the affected ones. I have seen a few recover by rupturing the pustules and sprinkling aristol on them.

In conclusion I may add that some weeks ago I received seven specimens of *Crotalus atrox* from San Antonio, Texas. Six of them are full grown; the other one is a small one of about eighteen inches in length, which is feeding lustily on Anolis. The venom of this little snake is evidently of considerable strength, for the death of the lizard ensues almost instantaneously after the bite. Three of the other six are evidently males. Sexual congress took place between one pair on May 14. The males are a little smaller and darker than the females. All are very excitable at present, any noise about the room being sufficient to start them to rattle. There seems to be absolutely no limit to their rattling. So far all of them have refused food. A young rat, which I put into the box, I had to remove again after two days, for the snakes never attempted to kill it.

CLASSIFICATION OF LAKES ACCORDING TO TEMPERATURE.

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In view of the increasing attention that is being given to the study of the temperature of the water in lakes and ponds it seems advisable to establish some system of classification by which we may group these bodies of water according to their temperature, thus giving additional value to the data accumulating on the subject. A suggestion for such a classification is here presented. It may add to a better understanding of the subject if we refer briefly to the temperature changes which take place in a body of water and the practical importance of the physical phenomena which they produce. We cannot do better, perhaps, than to take Lake Cochituate as an example and study it by the aid of the diagram in Fig. 1. The curves in this diagram are based on a seven years' series of weekly observations, but certain irregularities have been omitted for the sake of simplicity. If we trace the line of surface temperatures, we observe that during the winter the water immediately under the ice stands substantially at 32° F., though it may be added that the ice itself often becomes much colder than 32° at its upper surface. As soon as the ice breaks up in the spring the temperature of the water begins to rise. This increase continues, with some fluctuations, until about the first of August. Cooling then begins and continues regularly through the autumn until the lake freezes in December. If this curve of surface temperature were compared with the mean temperature of the atmosphere for the same period, a striking agreement would be noticed, and it would be seen that the water temperature is the higher of the two, — probably because of the direct heat received from the sun. In shallow ponds this effect is very marked, but in large, deep lakes,

where the water circulates to considerable depths, the atmospheric temperature is usually higher than the water temperature.

The temperature at the bottom of Lake Cochituate during the winter, when the surface is frozen, is not far from that of maximum density (39.2° F.). The heaviest water, therefore, is at the bottom and the lightest at the top, the intermediate layers being arranged in the order of their density. Repeated

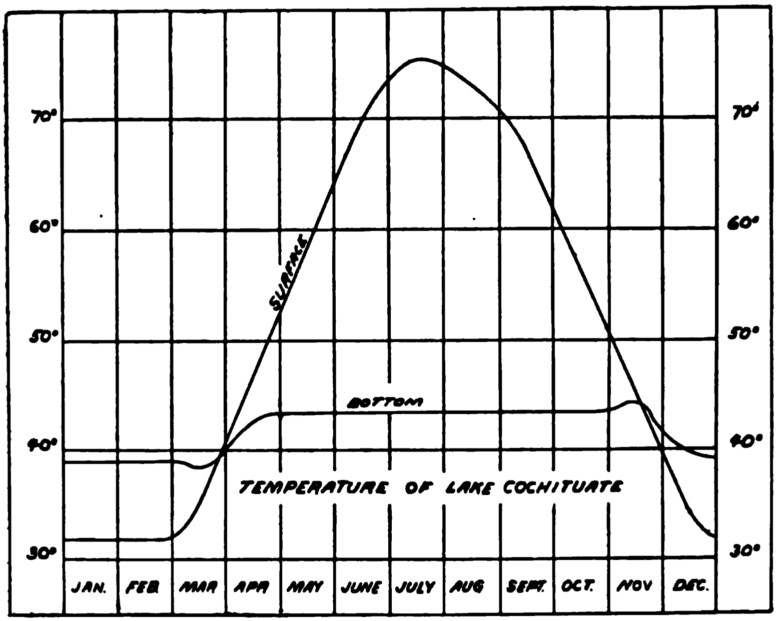


FIG. 1.

observations have shown that the colder water occupies a comparatively thin stratum under the ice, and that the temperature at a depth of ten feet is not much lower than at the bottom. With these conditions the water is in comparatively stable equilibrium. There is no tendency for it to circulate vertically. It is in a condition of "inverse stratification," as Forel calls it, when the colder water is above the warmer. It is the "period of winter stagnation." In the spring when the ice breaks up the cold surface water becomes mixed to a certain extent with the warmer water below it, and the bottom temperature drops

slightly. Soon the surface and bottom layers come to have substantially the same temperature, and vertical currents extend from top to bottom. This is the "period of spring circulation," or the "spring overturning." It lasts several weeks, but varies in duration in different years. As the season advances the surface water becomes warmer than that at the bottom, and finally the difference becomes so great that the wind is no longer able to keep up the circulation. Consequently, the bottom temperature ceases to rise, the water becomes "directly stratified," and the lake enters upon the period of "summer stagnation." During this period, which extends from April to November, the bottom temperature remains constant and the water below a depth of about twenty-five feet remains stagnant. This bottom temperature during the summer varies with different years, depending upon the meteorological conditions at the time when the period begins. In the autumn, as the surface cools, the water becomes stirred up to greater and greater depths, until finally the "great overturning" takes place, and all the water is in circulation. At this time there is a slight increase in the bottom temperature. Then follows the "period of autumnal circulation," during which the surface and bottom layers have substantially the same temperature. In December the lake freezes and "winter stagnation" begins.

Thus during the year there are two periods of circulation and two periods of stagnation. These physical changes have an important effect upon the quality of the water. During the stagnation periods much of the suspended matter in the water settles to the bottom, where there is already a large accumulation of organic matter. This decomposes, robbing the lower layers of water of all the oxygen present. Decomposition then goes on under the influence of the anærobic bacteria, and the water becomes charged with the products of decay. By the end of the stagnation period the lower layers have a very high color and a bad odor. At the overturning the foul water is carried into circulation, and its effect is noticed throughout the entire body of water. Nor is this all. The circulating water brings up from the bottom certain micro-organisms which have been lying dormant, and the products of decay alluded to

become changed into food material suitable for them; consequently, the organisms develop and the quality of the water suffers.

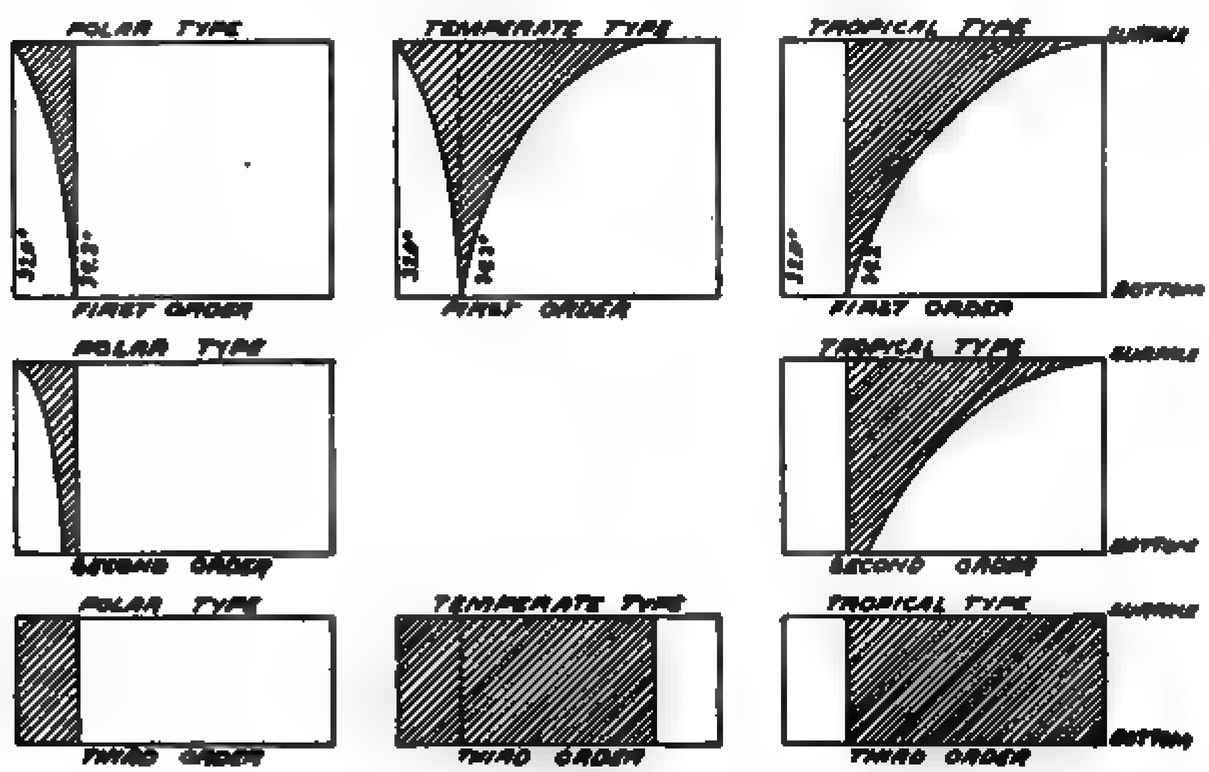
This matter of stagnation with its unpleasant effects is an important one for water-works engineers to study. The growth of organisms is closely connected with the presence of organic matter at the bottom. Observations have shown that if the organic matter is absent the organisms do not grow to any great extent. The best modern practice in the construction of reservoirs for water supply, therefore, indorses the removal of the soil from all areas to be flooded. This, however, is usually a matter of great expense, and, for that reason, some engineers do not consider it advisable to remove the soil from very deep reservoirs. In the opinion of the writer this position is well taken only in the case of reservoirs so situated and so deep that there is practically no circulation of the water at the bottom, and, therefore, no opportunity for any foul matter to be carried upwards.

The requisite depth for the attainment of such a condition is at present unknown. We know that in some very deep lakes the water at the bottom remains constantly at the temperature of maximum density, but we do not know how much this depth must be diminished in order to have circulation take place. Moreover, the depth is not the only factor concerned. The size and shape of the lake, its geographical location, and the nature of the surrounding country all have their effect upon the circulation of the water. As the vertical circulation of water can be studied best by means of its temperature, we see how valuable it would be to have regular and continued temperature observations made at various depths in our deep lakes and ponds. The observations thus far made are far too few to enable us to establish the point desired.

According to the classification here suggested, lakes and ponds are divided into three types, according to their surface temperatures, and into three orders, according to their bottom temperatures. The resulting nine classes are shown in Fig. 2. On these diagrams the boundaries of the shaded areas represent the limits of the temperature fluctuations at different depths.

The horizontal divisions represent temperatures in Fahrenheit degrees increasing towards the right, and the vertical divisions represent depth. The three types of lakes are designated as *polar*, *temperate*, and *tropical*. In lakes of the polar type the surface temperature is never above that of maximum density; in lakes of the tropical type it is never below that point; in lakes of the temperate type it is sometimes below and sometimes above it. This division into types corresponds somewhat closely with geographical location.

The three orders of lakes may be defined as follows: lakes of the first order have bottom temperatures which are prac-



CLASSIFICATION OF LAKES

Fig. 2.

tically constant at or very near the point of maximum density; lakes of the second order have bottom temperatures which undergo annual fluctuations, but which are never very far from the point of maximum density; lakes of the third order have bottom temperatures which are seldom very far from the surface temperatures. The division into orders corresponds in a general way to the characters of lakes; *i.e.*, size, contour, depth, surrounding topography, etc.

This classification is essentially the same as that recently proposed by Forel. He divides lakes into three types, polar,

temperate, and tropical, but bases the distinction upon bottom temperatures instead of surface temperatures, as follows:

1. *Tropical Type:* Temperature of deep layers varies from and above maximum density.

2. *Temperate Type:* Temperature of deep layers varies above and below maximum density.

3. *Polar Type:* Temperature of deep layers varies from and below maximum density.

He subdivides each type into two classes, deep and shallow, defining deep lakes as those which have a constant bottom temperature, and shallow lakes as those which have a variable bottom temperature. This subdivision is not a happy one, as observation shows that there are many lakes which would unquestionably be called "deep" which have a variable bottom temperature.

The temperature changes which take place in the nine classes of lakes according to our system of classification are exhibited in another manner in Fig. 3. These diagrams show by curves the surface and bottom temperatures for each season of the year, the times being plotted as abscissæ and the temperatures as ordinates. The shaded areas show the difference between the surface and bottom temperatures, the wider the shaded area, the greater being the difference.

A study of these diagrams brings out some interesting facts concerning the phenomena of circulation and stagnation. In Fig. 2 it will be seen that the circulation periods occur when the curve showing the temperatures at various depths becomes a vertical line; that is, when the water all has the same temperature. The stagnation periods are shown by the line being curved, the top to the right when the warmer layers are above the colder, and to the left when the colder layers are above the warmer. In Fig. 3 the circulation periods are indicated by the surface and bottom temperature curves coinciding, and the stagnation periods by these lines being apart. The distance between the lines indicates, to a certain extent, the difference in density between the top and bottom layers, and we see that the farther apart the lines become the less likelihood there is that the water will be stirred up by the wind.

In lakes of the polar type there is but one opportunity for vertical circulation (except in the third order), namely, in the summer season, when the water approaches the temperature of maximum density. In a lake of the first order, that is, in one where the bottom temperature remains constantly at 39.2°, the circulation period would be very short indeed, if not lacking altogether. In a lake of the second order circulation might and

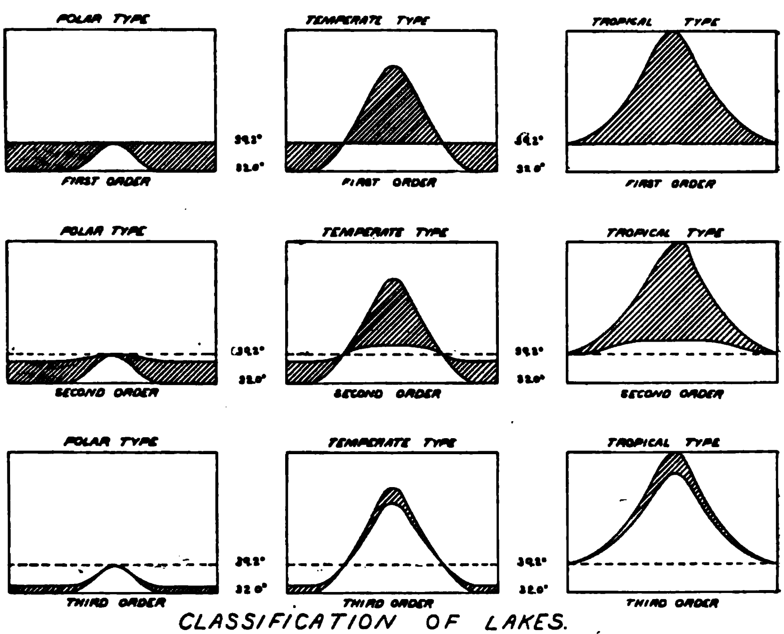


FIG. 3.

probably would continue for a longer period. In a lake of the third order the water would be in circulation nearly all the time except when frozen. The minimum temperature limit indicated for this order, *i.e.*, 32° at all depths, would be possible only in very shallow bodies of water, and would simply indicate that all the water was frozen; the temperature of the ice would probably be below 32° at the surface. It is probable that very few polar lakes exist.

In lakes of the tropical type there is likewise but one period of circulation each year (except in the third order). This would

occur not in summer, but in winter. In the first order this circulation period would be brief or entirely wanting; in the second it would be of longer duration; in the third order the water would be liable to be in circulation the greater part of the year. Tropical lakes are quite numerous, but observations are lacking to place them in their proper order.

Most of the lakes of the United States belong to the temperate type. In this type there are two periods of circulation and two periods of stagnation (except in the third order), as we have seen illustrated in the case of Lake Cochituate. In lakes of the first order the circulation periods would be very short or entirely wanting; in the second order the circulation periods would be of longer duration; in the third order the water would be in circulation throughout the year when the surface was not frozen.

If we recapitulate in tabular form, we have the following:

CIRCULATION PERIODS.

	POLAR TYPE.	TEMPERATE TYPE.	TROPICAL TYPE.
1st Order.	One circulation period possible, in summer, but generally none.	Two circulation periods possible, in spring and fall, but generally none.	One circulation period possible, in winter, but generally none.
2d Order.	One circulation period, in summer.	Two circulation periods, in spring and autumn.	One circulation period, in winter.
3d Order.	Circulation at all seasons, except when surface is frozen.	Circulation at all seasons, except when surface is frozen.	Circulation at all seasons.

Speaking in very general terms, we may say that lakes of the first order have no circulation; lakes of the third order have no stagnation (except in winter); and lakes of the second order have both circulation and stagnation.

In view of the comparatively few series of observations of the temperature of our lakes, the writer refrains from making any classification of the lakes of the United States, but the

results thus far obtained seem to indicate that the first order will include only those lakes more than about two hundred feet in depth, such, for instance, as the Great Lakes, Lake Champlain, etc.; the second order will include those whose depth is less than about two hundred feet, but greater than about thirty feet; and the third order will include those whose depth is less than twenty-five feet. These boundaries are only approximate, and it should be remembered that depth is not the only factor which influences the bottom temperature.

Instead of citing long tables of figures giving the results thus far obtained, which would materially lengthen this paper, the writer prefers to cite a list of references which the reader may consult.

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BOTANICAL ASPECTS OF JAMAICA.

DOUGLAS HOUGHTON CAMPBELL.

On May 27, 1897, in company with Prof. D. T. MacDougal, the writer sailed from Boston for Jamaica to make an inspection of the island, for the purpose of determining its availability for the location of a tropical station for botanical research.

The voyage was neither eventful nor, the first part at least, pleasant, as a cold rain prevailed much of the time, making a stay on deck impossible, except at the expense of a thorough drenching. About the fourth day out it grew warmer, and the bright blue of the water, with great masses of floating gulf weed, announced our approach to the tropics. On the fifth day land was sighted, — Watling's Island, or, as we knew it in our histories, San Salvador. Gazing at the low shore line, with its white lighthouse, we tried to imagine the sensations of Columbus when he first saw this outpost of the American Continent. The next morning we were rounding the barren shores of southeastern Cuba, and coasted the southern shores of that island nearly all day. We had now left the chilly air and dark waters of the North Atlantic and were enjoying genuine tropical weather. The vivid blue waters of the Caribbean Sea and the hot sunshine spoke eloquently enough of low latitudes.

The sun set before we came in sight of Jamaica, and it was past midnight when the light of Port Antonio could be distinguished. Although it was intensely dark, the land breeze, bearing indescribable scents of the land, and the chirping and buzzing of innumerable insects told us we were near *terra firma*.

As soon as we could have our baggage passed through the custom-house we drove at once to the hotel, where the comfortable beds and spacious rooms were very welcome after the confined quarters on shipboard. On awakening the next morning our eyes were greeted with the sight of cocoa palms, breadfruit trees, bananas, and other evidences of the tropics.

The warm, humid atmosphere was not especially conducive to hard work, especially after the chilly air we had left behind us, and for a few days we contented ourselves with becoming acquainted with the immediate surroundings of the beautiful harbor of Port Antonio. This is the principal port of the northern side of the island, and is most beautifully situated within sight of the Blue Mountains, the highest range in Jamaica. The shore formation is largely coral, and the rocks are covered with luxuriant vegetation to the water's edge. The heavy rainfall — about one hundred and fifty inches annually — induces a marvelously rapid growth of all kinds of plants, and everything is fairly buried in the rank growth. Along the coast cocoanut palms abound, and where the shores are muddy mangrove swamps are a conspicuous feature.

Although most of the country about Port Antonio is under cultivation, cocoanut and banana plantations predominating, still the native vegetation quickly takes possession of the neglected lands, and roadsides and hills furnish abundant and interesting material for the botanical collector. Among the most unfamiliar plants to Northern eyes are the climbing aroids, Philodendron and Syngonium, which, with their terrestrial relatives, Alocasia, Dieffenbachia, and other less common forms, contribute much to the tropical aspect of the prevailing vegetation. The sensitive plant is a common weed, and showy Thunbergias and other creepers abound. Of the ferns the most noticeable forms were a very common Anemia, and at slight elevations Gleichenia and a very beautiful Lygodium. Various Alsophilas and other tree ferns were not uncommon, but not nearly so fine as those at higher altitudes. A climbing Davallia, with prickly stems, was also conspicuous.

A railroad now connects Port Antonio with Kingston, which lies upon the southern shore of the island. The trip over this road is a most enjoyable one, as it traverses some of the most picturesque parts of the island and gives an excellent idea of its general topography and vegetation. For about thirty miles the road skirts the seashore, showing in places sandy beaches, but more commonly coral rock coming down to the water, carved into fantastic shapes by the action of the waves.

Along the sandy beaches *Ipomoea pes-caprae* abounds, and with this the curious "shore grape," Coccoloba, and other characteristic forms are common. In many places are depressions just back of the shore, and these form swampy jungles, with the trees laden with a perfect tangle of lianas and other epiphytic growths. Here and there in the more open places are groups of prickly stemmed "groo-groo" palms (Acrocomia), — the first indigenous palms we had seen.

Leaving the shore, the road passes over the mountains and part of the time is in sight of the forest, although for the most part the land along the route of the railroad is under cultivation. As we ascend the tree ferns become common, and a number of beautiful palms are noticed, among them the superb cabbage palm, *Oreodoxa oleracea*, with its slender, straight shaft shooting up sometimes a hundred feet and more. Gigantic bamboos cover the hillsides and grow in great masses along the streams, their exquisite green plumes being among the most beautiful of vegetable growths. This magnificent plant has been introduced probably from India, but is now thoroughly naturalized all over Jamaica.

As the summit is passed and the descent toward the southern side of the island begins, a difference in the character of the vegetation soon becomes apparent, and the very much diminished rainfall on this side of the island is at once indicated by the very different plants met with. This becomes more and more marked as Kingston is approached. Leguminous trees, Prosopis, logwood (Hæmatoxylon), Pithecolobium, characteristic of a drier region, are common, and several Cacti, Opuntias, and species of Cereus give a very distinct stamp to the landscape. The contrast between the semi-arid country about Kingston and the rank luxuriance of the vegetation at Port Antonio is most striking.

At Kingston we were met by Mr. Fawcett, the director of the public gardens of the island, who throughout our stay did everything possible to aid us in our work. Had it not been for his kindness it would have been quite impossible for us to have made our trip as successful as it was.

While in Kingston we were entertained at Mr. Fawcett's charming home in the Hope Gardens, about six miles from the town. This garden is comparatively new, but is becoming rapidly a most beautiful and interesting experimental station. Extensive plantings are being made which will add greatly to its attractiveness and usefulness.

The first trip made by us was to Castleton, the seat of the most interesting of the botanical gardens of Jamaica. We drove from Kingston, about nineteen miles, over a most picturesque road, the vegetation becoming more and more luxuriant as we approached the garden, where there is an average rainfall of about one hundred inches. A few hours only were spent at this time at Castleton, but later Professor MacDougal and myself returned for a stay of several days, during which we became better acquainted with the many attractions of this most beautiful garden. It is situated at an elevation of about six hundred feet, and contains a remarkable collection of palms and other tropical plants. Of the former there are about one hundred and fifty species, and among the other notable plants was a fine collection of cycads, comprising many magnificent specimens, which appear to thrive to perfection; screw pines, tree ferns, and many pretty epiphytic orchids, as well as innumerable showy flowering trees and shrubs, made the finest display we encountered anywhere. Of the flowering trees *Amherstia nobilis*, with its hanging clusters of gorgeous scarlet flowers, was, perhaps, the most beautiful; but among other showy trees were noticed a Lagerstrœmia, with big, lilac-colored flowers, and a Spathodea, whose flame-colored cups and deep green leaves formed a magnificent spectacle.

The country all about is very mountainous, and a trip to the higher regions yielded a number of most interesting ferns and liverworts, as well as many flowering plants not found on the lower levels.

A trip was made later to Blue Mountain Peak, the highest point in the island, rising over seven thousand feet above sea level. This excursion, which was taken in company with Mr. Fawcett, was in all respects a most enjoyable one. The trip was made from Kingston, and after the first nine miles was

done on horseback, as the mountain roads are not available for vehicles. The native ponies are very sure-footed, however, and the trip offers no hardships, and more than repays one, both scenically and botanically, for the trouble. The scenery is of the most magnificent character, with fine views in all directions. This is the principal coffee-growing district, and on all sides were extensive plantations, many of them very old. Here and there were the works for storing and curing the berry, great heaps of which could be seen in places spread out upon the concrete platforms, "barbecues," to dry in the sun.

We visited the Hill gardens, "Cinchona," where there are plantations of cinchona trees, whose cultivation, however, no longer is profitable. Most of the plantation lies about five thousand feet high, and here the conditions are favorable for the growth of many subtropical and temperate plants, as the temperature is never extreme.

In the neighborhood of Cinchona were found the finest collecting grounds for ferns met with anywhere. In the shady, moist ravines there was a profusion of fern growths far exceeding anything I have ever seen. The tree ferns, various species of Alsophila and Cyathea, were magnificent; some of them could scarcely have been less than forty feet in height, their graceful, slender trunks crowned with the exquisitely cut leaves looking like the finest lace overhead against the sky. The undergrowth was largely composed of a bewildering variety of ferns, from big Marattias and Alsophilas, with leaves ten or fifteen feet long, to tiny Hymenophyllums, looking more like delicate mosses than ferns. Other interesting plants were Danæa, several species of Gleichenia and Davallia, and many fine liverworts and mosses. A rather unexpected find was a Sphagnum, which occurred in large beds along the roadside in one place. The occurrence of Sphagnum, as well as other Northern plants, such as *Lycopodium clavatum*, *L. complanatum*, *Fragaria vesca*, blackberries, and buttercups, mixed with beautiful pink begonias, Gleichenia, and other tropical types, showed the meeting of the Alpine and lowland floras.

The ride from Cinchona to the summit, about two thousand feet above it, did not reveal any very marked differences in the

plants encountered, although at the summit itself the trees were somewhat dwarfed. Among the most characteristic trees of the higher altitudes was a Vaccinium, *V. meridionale* Sw., and *Podocarpus coriaceus* Rich. Tree ferns abounded, but were not so fine as those somewhat lower down.

From the peak fine views may be had in clear weather in both directions. On the north is the harbor of Port Antonio, and on the south that of Kingston. We did not enjoy the fine view very long, as a shower of rain came up which obliged us to descend sooner than we had expected, but not before we had time to get a good idea of the vegetation.

A most enjoyable trip was one made by the writer in company with the late Dr. Humphrey, in whose untimely death in Jamaica, shortly after our departure, botany has suffered so severe a loss. This trip was over the mountains from Port Antonio to Bath, the site of the first botanic garden established in Jamaica some hundred years ago, but now reduced to a fraction of its original area. It still contains some fine specimen trees, especially palms and Pandanus, but there are a number of other fine trees still remaining. The road over the mountains is a rough bridle path, which at the Cuna-Cuna pass reaches an altitude of about three thousand feet. It is proposed to make a carriage road, which will be, when complete, one of the most beautiful in Jamaica, as it passes through a most picturesque region, including the finest forests we saw anywhere. The whole district is one of very heavy rainfall and the vegetation wonderfully varied and beautiful. The road over the pass is through virgin forest of the most luxuriant description. Ferns in great variety abound, and in some places thickets of beautiful palms, *Euterpe oleracea*, formed a striking feature of the forest. These palms, with the tree ferns, large aroids, and epiphytic Bromeliads and orchids gave a thoroughly tropical aspect to the vegetation. There were numerous epiphytic orchids, but only a few in flower. Of these a yellow and brown Oncidium was most conspicuous, the great hanging panicles of flowers looking like a swarm of small butterflies. A great variety of showy Scitamineæ, Heliconia, Hedychium, Canna, and others were common, and among

the lower plants were several tropical liverworts, among them Dendroceros, Symphyogyna, and Monoclea.

The little town of Bath lies close to the base of the mountains, and, besides its ancient garden, is famed for its hot mineral baths. The town was formerly much more important than at present, and there are still some of the fine old trees left, planted by a former generation. Among these are grand specimens of the stately *Oreodoxa oleracea*, the finest of all the Jamaica palms. This tree, with its smooth, slender shaft a hundred feet in height and its crown of green plumes, is indeed one of the most beautiful of plants.

As may be gathered from the foregoing sketch, the flora of Jamaica is extraordinarily rich and varied. The presence of high, abrupt mountains results in extremely different conditions both of temperature and moisture, and this is evident in the very divergent character of the plants of the different sections of the island. As we have seen, the prevailing vegetation is distinctly tropical, and, as might be expected, related to that of the Central and South American mainland. Considering the size of Jamaica the number of indigenous palms is surprising. Of the strictly American types of plants the Bromeliads are the most noticeable, although the Cacti, Agaves, and Yuccas are represented. The Bromeliads occur in nearly all parts of the island, and form an important factor in the rich epiphytic flora. One of the most characteristic sights is a large cotton tree (Eriodendron) with its great horizontal branches covered with a mass of epiphytes, conspicuous among which are many Tillandsias and other bromeliaceous forms.

Of orchids the island has about sixty species, many of them epiphytes, most of which are not especially showy. Besides the Oncidium already mentioned, there are pretty Epidendrums, and an exceedingly brilliant little crimson species, *Broughtonia sanguinea*, was common in several localities. Of the terrestrial orchids in flower the finest were two species of Bletia, recalling our own Calopogon, and a magnificent Phajus, which is said to have been introduced from Asia.

The aroids are among the noticeable plants, many striking species being common. Several species of Philodendron are

exceedingly abundant, climbing high up the trunks of trees or clambering over rocks; Syngonium, closely resembling Philodendron, is also abundant, and species of Anthurium, Dieffenbachia, and other genera abound in the more moist localities. The floating *Pistia stratiotes* is a common inhabitant of ponds and quiet rivers.

Several species of Cacti are common, especially in the drier parts, where one columnar Cereus is often used for fences. One great night-blooming species, *C. triangularis*, almost covered the trees in places. Two species of Rhipsalis were common at various places visited.

Other striking plants were the innumerable lianas, draping and almost smothering the trees. Some of these were leguminous climbers, others Convolvulaceæ, Vitaceæ, Thunbergias, Allamandas, and a great many which there was not time to identify. Some of the showiest flowers seen belonged to these creepers. Many other interesting plants were noted, but those cited are enough to give some idea of the tropical character of the flora.

All the ordinary cultivated plants of the tropics grow with very little care, and many have become practically spontaneous. Fruit-growing has assumed great importance of late, and is becoming yearly more and more important.

Except the ferns and liverworts no very careful studies were made on the lower plants. Probably no region of equal extent in the world is richer in ferns than Jamaica. About five hundred species have already been described, and there are probably many more to be discovered, as very little collecting has been done in the more inaccessible parts of the island. The ferns comprise all the tropical types, the Hymenophyllaceæ alone being represented by some fifty species. The Cyatheaceæ include the tree ferns, Cyathea, Alsophila, Hemitelia, which are numerous and of very large size and wonderful beauty. Of the Marattiaceæ, *Marattia alata* and several Danæas are not uncommon in the higher mountains, and the Schizæaceæ comprise species of Schizæa, Lygodium, and Anemia. Gleichenias of several species are common and conspicuous ferns. The Ophioglossaceæ are scarce and none were encountered,

although several species belong to the island. Of the heterosporous ferns the only one met with was *Marsilia polycarpa*.

Several species of Selaginella and Lycopodium were common, and *Psilotum triquetrum* was encountered once, but is evidently rare.

The liverworts are comparatively scarce at the lower levels, but amazingly abundant and varied in the higher altitudes, where the ferns also reach their maximum development.

Algæ were less abundant than had been expected, and lack of time did not permit a careful study of this group. Owing to the very slight tide — only about one foot — very little collecting can be done from the shore, and we were not provided with apparatus for collecting in deep water. The most interesting forms noted were the marine Siphoneæ, Caulerpa, Halimeda, and others. Probably this group is well represented and would repay careful study. Fungi also were less abundant than might have been anticipated.

In considering the localities best fitted for the establishment of a laboratory, there is little question that the eastern part of the island offers much the best conditions, as here there is the maximum rainfall with the resulting luxuriant vegetation. Port Antonio, lying on the coast and being very accessible, as well as offering excellent living accommodations, is in many respects a favorable locality, but is rather too far from the higher altitudes and virgin forest. Bath is nearer to the latter and is fairly easy of access, but is seven miles inland.

The writer cannot close this sketch without acknowledging the many kindnesses shown us on our trip by every one with whom we came in contact. Through the courtesy of the director of the island railways, Mr. McKinnon, we were provided with passes over all the lines, and were also offered other help which lack of time prevented our accepting. The governor of Jamaica, Sir Henry Blake, and the authorities of the Institute of Jamaica also showed great interest in our plans and helped us in many ways. It is to Mr. W. Fawcett, however, that we are especially indebted, and to whom much of the success of our trip is due.

THE WINGS OF INSECTS.

J. H. COMSTOCK AND J. G. NEEDHAM.

CHAPTER I.

An Introduction to the Study of the Homologies of the Wing-Veins.

IT is the purpose of this series of papers to present a summary of what is known regarding the structure and development of the wings of insects, to give the results of some investigations in these fields made by the writers, and to indicate the value in taxonomic work of the characters presented by the wings.

As the growth of our knowledge naturally proceeds from a study of the obvious facts of nature to those that are more deeply hidden, it seems best to discuss first the structure of the wings of adult insects and to postpone for a time the study of the beginnings of wings. It will be necessary, however, to take up early in the discussion a study of the structure of the wings in those stages that immediately precede the adult stage, the pupæ of insects with a complete metamorphosis, and the nymphs of insects with an incomplete metamorphosis. It is in this field that we have the most to offer that is new.

Several writers have appreciated the fact that much light can be thrown on the problem of determining the homologies of the wing-veins by a study of the tracheæ that precede them in the wings of immature insects. The more important of the contributions that have been made to this phase of the question are those of Brauer and Redtenbacher[1] and of Spuler.[2] Still, comparatively little has been done in this direction.

This is doubtless due to the difficulties that have stood in the way of work of this kind. The tracheæ of the wings of pupæ and nymphs are often very delicate, and when filled with

[1] Brauer und Redtenbacher, Ein Beitrag zur Entwickelung des Flügelgeäders der Insecten. *Zool. Anz.*, 1888, pp. 443–447.

[2] A. Spuler, Zur Phylogenie und Ontogenie des Flügelgeäders der Schmetterlinge. *Zeit. f. wiss. Zool.*, Bd. liii, 1892, pp. 597–646.

the medium in which a wing is mounted for microscopic study they are usually invisible. It is not strange, therefore, that they have been studied so little. But in the course of our investigations we have devised a method of study of the wings of immature insects which renders the observation of the tracheæ in them a simple matter.

If a living pupa or nymph be placed in formol (4%) the tissues of the wings will be rendered translucent in a short time. In the case of very delicate insects only a few hours

Fig. 1. — Part of a wing of a pupa of *Corydalis cornuta*.

are required for this, but with larger ones with more opaque wings it is necessary to leave them in the formol for several days, or even for several weeks. While the formol renders the tissues translucent, it does not soon penetrate the tracheæ, which are, therefore, left filled with air, and appear as dark lines when the wing is examined with transmitted light. Just after molting some wings are translucent, but there are few so clear that a short stay in formol will not make them clearer.

In order to study wings prepared in this way, they are removed from the body and mounted in glycerine jelly, care being taken to cool the mount quickly so that the jelly will not

penetrate the tracheæ. In this way most beautiful objects can be prepared, which will show the minutest ramifications of the tracheæ.[1] Fig. 1 is a half-tone reproduction of a photograph of an object prepared in this way. This figure represents a small portion of a wing of a pupa of *Corydalis cornuta.*

Not only can the tracheæ that precede the wing-veins be studied in this manner, but, if the wing be taken at the right stage, the cuticular thickenings destined to form the wing-veins, as well as their corresponding tracheæ, if there be any, can be seen. Figs. 2 and 3 are half-tone reproductions of photographs of wings taken at this stage.

There is, however, one undesirable feature of preparations made in this manner; it is that after a time the cuticular thickenings become indistinct, and the glycerine jelly will penetrate the tracheæ, rendering all except the larger ones invisible. But as it is a very easy matter to photograph such preparations, and as a series of photo-micrographs are much more easily compared than a series of microscopic slides, this feature does not materially impede an investigation of this kind. Usually the cuticular thickenings show best as soon as a mount is made, while the tracheæ stand out more sharply twenty-four hours after mounting, because of the clearing effect of the glycerine jelly upon the cuticular parts. It is, therefore, frequently desirable to make, at different times, two or more photographs of the same specimen.

[1] In making mounts of this kind our usual procedure was to spread a drop of melted glycerine jelly on a slide and allow it to cool; then to dissect off the wings (generally under water), taking with them just enough of the thorax to include the basal attachments of the tracheæ; then to place these wings upon the solidified glycerine jelly on the slide; then to lower upon the wings a heated cover glass, causing the jelly to melt enough to envelope the wings; and then to cool the mount speedily on a cake of ice, a marble slab, or in a draught of cold air. Rapid cooling is imperative, for in melted glycerine jelly the tracheæ soon become filled, and the smaller ones are then invisible.

It is imperative, also, that the wings be handled with care. Being simple sac-like structures, the tracheæ are almost free within them, and a slight pinch with forceps in the middle of the wing may throw all of its tracheæ out of place. It is better to lift the wing by its thoracic attachments or upon a section lifter.

Not every pupal wing is fitted for this study. Just before molting, and especially just before the last molting, the wing becomes so crumpled within its old sheath that the course of its tracheæ can be followed only with difficulty. Much time can be saved by the selection of the paler individuals for study.

It is obvious that one who has learned the homologies of the principal tracheæ of wings can easily determine the homologies of the wing-veins of the adult by the study of wings taken in the stage of development shown by Figs. 2 and 3. It should be remembered, however, that the determining of the homologies of these tracheæ necessitates the study of a large series of well-selected types. One is not warranted in arriving at conclusions in this matter from the study of a few representatives of a single order of insects.

During the past year we have studied in the manner indicated the wings of representatives of nearly all of the more important groups of winged insects, and have made several

FIG. 2. — Fore wing of a nymph of Nemoura.

hundred photo-micrographs of them. We feel, therefore, that we have at hand sufficient data to warrant the conclusions regarding the homologies of the wing-veins that we purpose to offer.[1]

Although Figs. 2 and 3 will be discussed in detail in a subsequent chapter, we will give a few words of explanation here. These figures represent the wings of one side of a nearly mature nymph of a Nemoura, one of the genera of stone flies (Plecoptera). In making the preparations it was impracticable to remove all of the dirt adhering to the wings without danger of injuring them; this is often the case in preparing mounts of

[1] The most important gap in our series of observations is due to the fact that as yet we have been unable to procure pupæ of any of the Mecoptera. We would, therefore, be under great obligations to any one who would send us living pupæ of either Panorpa or Bittacus.

the wings of aquatic nymphs. The irregular blotches of dark color in the figures are due to this cause. The dark lines traversing the disk of the wing represent the tracheæ, and the pale bands the cuticular thickenings destined to form the wing-veins.

It will be observed that the principal veins are formed along the courses of tracheæ, while in most cases the cross-veins have no tracheæ within them. It will also be observed that the tracheæ extend in straight lines or in gentle curves, while in some cases the corresponding veins are much more angular.

It is evident from this that in the perfecting of a wing as an organ of flight the position of a vein in the adult may become

FIG. 3. — Hind wing of a nymph of Nemoura.

quite different from that of the corresponding trachea of the immature form. In other words, although there is no doubt that the courses of the principal wing-veins of primitive insects were determined by the position of the principal tracheæ of the wings, the wing-veins have been more or less modified to meet the needs of adult life; while at the same time the tracheæ of the immature wing, serving the purpose of respiration, and lying more or less free within the wing-sac, have not been forced to follow closely the changes in the cuticular thickenings of that sac.

The operation of this principle is shown only to a slight extent in the wings figured here. But when we study more highly specialized forms, it is seen that the divergence of these

two sets of structures is sometimes very wide, and must be taken into account in an interpretation of the characters presented by a wing.

While this increases the difficulty of determining the homologies of the wing-veins, it is often of great aid in taxonomic work, for it may afford an indication of the degree of divergence from a primitive type in the structure of a wing; and when a series of forms is studied the course of this divergence is often clearly indicated.

The figures also show that in some cases what appears as a single vein is formed about two closely parallel tracheæ. This is shown in the case of the bases of the second and third principal tracheæ, counting from the costal margin of the wing, the radial and medial tracheæ. This illustrates a fact of frequent occurrence, — that what appears to be a single vein may be formed by the coalescence of two primitive veins.

In these figures the tracheæ just mentioned, except one of them in the fore wing, appear not to extend to the base of the wing. This is due to the fact that in the preparations photographed the mounting medium had penetrated these tracheæ for a distance, rendering the basal portion of them invisible.

The figure of the hind wing illustrates also another way in which specimens may be injured during their preparation, and which may lead to a misinterpretation of them. In this wing the first branch of the first main trachea, the subcostal trachea, has been broken and moved out of place within the wing-sac. The normal position of this branch is well shown in the figure of the fore wing.

We will not go farther into the discussion of the technique of this method of study. Enough has been said to show that we have at hand a comparatively simple method of determining those questions of homologies of wing-veins that have sorely puzzled all investigators that have attempted to deal with them, and to indicate the nature of the material upon which we have based the conclusions that we purpose to offer in succeeding chapters of this paper.

ENTOMOLOGICAL LABORATORY,
CORNELL UNIVERSITY, November, 1897.

EDITORIAL.

The Aim of the American Naturalist. — The thirty-second volume of the *American Naturalist*, which commences with the present number, will be the first entire volume to appear under the new management. It may not, therefore, be inappropriate at this time to state once more the motive which has induced us to assume control of the magazine.

Every enterprise that hopes to be successful must be conducted with some one definite aim in view. From the range of subjects covered by the *Naturalist* it may be supposed by many that the magazine is to be a kind of scrap basket for a miscellaneous lot of articles which, for one reason or another, have failed to find space in the journals of the special sciences to which they rightly belong. This is just what we most earnestly desire to avoid. We wish to select our articles so that the magazine shall have a definite character, with each department working in harmony with all the rest. What, then, is to be the basis of selection? What common point of view shall cement its diverse departments into a harmonious whole?

There was a time, hardly antedating the foundation of this journal, when one man might be equally eminent as a zoologist, a botanist, and a geologist. Many of the most distinguished names in science are borne by men whose activities ranged over all of these broad fields. But the conditions have been so changed by the rapid accumulation of knowledge during the last half-century that in order to attain any success a man must devote his attention to a narrow field; and, instead of becoming naturalists in the broad sense of the term, we see men becoming lepidopterists, coleopterists, ornithologists, embryologists, and the like, devoting their entire attention to one small group of animals or plants, to a narrow line of investigation in morphology or physiology, or studying exclusively some small class of phenomena in geology or mineralogy. Instead of the general scientific journals and societies of natural history of former times, these conditions have called into life and elevated to the highest prominence societies and journals dealing with the special problems of restricted lines of research. Such conditions obtain to-day, and must continue to influence the course of investigation so long as unknown facts remain to be discovered.

But can we not see already the dawn of a new era in natural science, brought about by this very multiplicity of independent researches and vast accumulation of material? Generally speaking, the obvious facts of natural science have been discovered, and investigation is trending away from them toward the deeper, more remote, and more fundamental phenomena. Students following these deeper lines of research sooner or later find themselves on the border where their scientific field touches their neighbor's. The morphologist who seeks to explain the causes of development soon finds himself involved in questions of physiology. Physiologists, on the other hand, in studying the functions of the nervous system, for example, have found it possible to draw important conclusions from data furnished by morphology. The geologist supplies the biologist with information concerning the conditions that have influenced the geographical distribution of organisms, and learns from him in turn what organisms have to teach as to the nature of the environment in which strata have been deposited. And so it is throughout all the related sciences. A good example of this tendency is furnished by the program of the American Morphological Society, which is holding its meeting as we go to press. We notice such titles as the following: "Grafting Experiments upon Lepidoptera," "The Effect of Salt Solutions on Unfertilized Eggs of Arbacea," "Some Activities of the Polar Bodies of Cerebratulus," "The Reaction of Amœba to Light of Different Colors and to Rœntgen Rays." Surely we may expect these papers to contain as much physiology as morphology.

A movement seems to be well under way toward a closer union of the natural sciences based not upon superficial observations and poorly grounded speculations, but upon a deeper insight into the real facts. It is the purpose of the *American Naturalist* to aid and encourage this movement. We desire that our pages afford a common meeting-ground where the morphologist, the physiologist, the zoologist, the botanist, the anthropologist, the palæontologist, the geologist, and the mineralogist may meet to discuss the problems in which they have a common interest. But it is not merely articles dealing in broad generalities that we want. Accounts of the most minute investigations will be cordially welcomed, if only the results are shown to have some significance from our point of view.

Of course, ultimately, all human knowledge is a unit, and no fact lacks significance; but we have no ambition to cover such a field. How, then, shall we define our province?

May it not be possible to regard the earth and its inhabitants as a unit? Then the problem would be to describe the various parts of this unit and to explain their relations to one another. While the solution of this problem is too vast an undertaking for any one man or any generation of men, may it not be legitimate to adopt it as the final purpose of a journal which is intended to represent the great body of naturalists in this country? It seems to us that this is a legitimate ideal of attainment, and one which, if kept steadily in view by editors and contributors, will afford that unity of purpose which is essential to success.

But in order to be truly representative and to attain the highest success, we need the coöperation of every naturalist in America. We are glad of your subscriptions, but we especially desire your contributions. To every one who has anything interesting to say we extend a cordial invitation to use our columns. If the editors are allowed to choose from the best that is produced, they will find no difficulty in issuing a magazine that Americans may be proud to call the *American Naturalist.*

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Report of the Bureau of Ethnology.[1] — In the introduction to the administrative report Major Powell outlines more definitely than in the preceding volume his classification of ethnological activities. "The great science of demonomy," or the science of humanity, is divided into five categories: (1) esthetology, (2) technology, (3) sociology, in the sense of the science of government, (4) philology, with enlarged definition, (5) sophiology, the science of opinions. It is believed that the Bureau has organized and defined "the demotic sciences in such manner as to yield a definite basis for a scientific classification of the races and peoples of the earth."

The director announces that the vast collection of information obtained from personal research, manuscripts, and published literature concerning the Indians is to be published in a series of bulletins corresponding with the aboriginal stocks, under the designation "Cyclopedia of the American Indians." The subjects of the four accompanying papers are found in the pueblo region of the Southwest, in Yucatan, and in Peru.

The first of the two memoirs upon "extra-limital" subjects is not only of general, but also of comparative interest, since it aids in demonstrating the unity of aboriginal American culture. The conclusion is reached by Professor McGee that the operations of trephining were performed by persons of the same culture grade as the well-known "medicine men" of this continent, though but one case of trephining is thus far known in North America. In a collection of about one thousand crania two per cent were found to have been trephined, several more than once. Dr. Muñiz states that all the specimens pertain to a period at least two hundred years anterior to the discovery; they are from various and widely separated pueblos. No trephined crania have thus far been discovered at the necropolis of Ancon. Post-mortem trephining was not practiced, and no amulets of human bones have been found in Peru. The origin and development of this dangerous practice is discussed, and the methods

[1] *Sixteenth Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution*, 1894–95, by J. W. Powell, Director. Washington, Government Printing Office, 1897.

classed according to culture grades. Comparison is made with the customs of the South Sea Islanders and the Kabyles, among whom trephining has long been practiced with a heroic exhibition of fortitude and an even greater recklessness of consequences than among the Peruvians. The South Sea Islanders hacked and scraped the skull with stone and shell, and covered the wound with plates of cocoanut. The operation was performed in some cases for the relief of simple headache. The Muñiz series contains but six crania which indicate a therapeutic motive; these operations were performed to relieve traumatic lesions, and all resulted fatally.

The second paper, "The Cliff Ruins of Canyon de Chelly, Arizona," is accompanied by a map which shows the extent of the pueblo region within the limits of the United States. The Canyon de Chelly is located near the center of an area which embraces nearly all of Arizona, eastern and central Utah, western New Mexico, and a small portion of southwestern Colorado.

Mr. Mindeleff's observations show that the cliff dwellers were Indians, and not a race distinct from the neighboring tribes. The cliff houses were erected in easily defended situations, where ledges afforded foundations and roofs, and where suitable blocks of stone for the walls were abundant. The same people also possessed pueblos near their unprotected agricultural lands. Gradations are found from the cliff to the pueblo type of domicile.

Dr. Cyrus Thomas, in a publication entitled *The Maya Year*, has shown that the year recorded in the Dresden codex consisted of eighteen months of twenty days each. The origin and signification of the symbols in the Maya, Tzewtal, Quiche-Cakchiquel, Zapotic, and Nahuatl, representing each of these twenty days, form the subject of the paper entitled "Day Symbols of the Maya Year." The Maya scribes had not reached that advanced stage where they could indicate each letter sound by a glyph or symbol; yet the characters used were to a certain extent phonetic. The symbols were not true alphabetic signs, but syllabic, in some cases ideographic, or in others simply abbreviated pictorial representations.

The memoir by Dr. J. Walter Fewkes on "Tusayan Snake Ceremonies" deals with a modification, produced by peculiar environmental conditions, of the serpent cultus which extended from the St. Lawrence to Peru. The ceremonies observed at the Hopi villages of Oraibi, Cipaulovi, and Cuñopavi are described in detail, and the conclusion is reached that "the worship of a great snake plays no part, but the dance is simply the revival of the worship of the Snake

people, as legends declare it to have been practiced when the Tíyo was initiated into its mysteries in the world which he visited." "I am inclined to believe that the snake dance has two main purposes, the making of rain and the growth of corn, and renewed research confirms my belief, elsewhere expressed, that ophiolatry has little or nothing to do with it."

The Import of the Totem.[1] — Miss Fletcher's studies have been aptly characterized as "sympathetic and thorough," and the present paper fully demonstrates the truth of the observation. Within the limits of a few pages is given a remarkably clear and concise account of the idea of the totem, one of the most obscure and perplexing subjects with which the student of American ethnology has to deal.

The totem is based upon the Indian's belief concerning nature and life, and it is only through an explanation of his customs and practices, a knowledge of his rites and ceremonies, that we may come to know what this belief is.

There are two classes of totems among the Omahas: (1) personal, belonging to the individual, and (2) social, that of societies and gentes. The personal totem is obtained by means of a puberty rite in which the youth fasts until he sees or hears in a dream or vision some animal or other form. This thing becomes the special medium through which he can obtain supernatural aid. It is his duty to seek and slay the animal seen in his vision ('in cases where the vision has been of no concrete form, symbols are taken to represent it') and preserve some part of it. This amulet represented the power of the whole class to which it belonged, a conception growing out of the anthropomorphic projection of man's characteristics upon all nature and the belief in the continuity of life, "making it impossible for the part and the entirety to be disassociated."

"The totem's simplest form of social action was in the religious societies, whose structure was based upon the grouping together of men who had seen similar visions, . . . blood relationship was ignored." "In the early struggle for existence, the advantages accruing from a permanent kinship group, both in resisting aggression and in securing a food supply, could not fail to have been per-

[1] *The Import of the Totem: A Study from the Omaha Tribe.* By Alice C. Fletcher, Thaw Fellow and Assistant in Ethnology, Peabody Museum, Harvard University. A paper read before the Section of Anthropology of the American Association for the Advancement of Science at the Detroit meeting, August, 1897. Salem, The Salem Press, 1897.

ceived; and, if the people were to become homogeneous and the practice of exogamy continue, some expedient must have been devised by which the permanent groups could be maintained and kinship lines be defined. The common belief of the people, kept virile by the universal practice of the rite of the vision, furnished this expedient." "Social growth depended upon the establishment of distinct groups, and the one power adequate for the purpose was that which was believed to be capable of enforcing the union of the people by supernaturally inflicted penalties."

There were ten gentes in the Omaha tribe; exogamy prevailed, and descent was traced only through the father. "Each gens had its particular name, which referred directly or symbolically to its totem, which was kept in mind by the practice of tabu." The office of the totem in the religious societies, in the gentes, and the tribe is described, and the paper closes with a discussion of the linguistic evidence as to the import of the totem. FRANK RUSSELL.

GENERAL BIOLOGY.

A Study in Heredity.[1] — For the student of heredity no domestic animal is of greater interest than the American trotting horse and his brother, the pacer. The two are closely related; their development has been rapid and has taken place mainly during the latter half of the present century, and the records of ancestry and of speed, which have been kept accurately, give a measure of the inheritance of variations in a large number of correlated parts. It is, therefore, a real service to biologists, as well, no doubt, to breeders, that Mr. A. J. Meston is doing in bringing together in one work the main facts concerning the ancestry of the best trotters and pacers.

The first part of this work, dealing with the descendants of the horse known as Rysdyk's Hambletonian 10, is what we have now under review. That the remaining parts will not be long forthcoming is to be hoped, for each part will gain in value in proportion to the completeness of the whole.

The pamphlet before us opens with a list of the common sources of 2:10 speed arranged chronologically. Then follows an introduc-

[1] A. J. Meston, *The Common Sources or Main Taproots of 2:10 Trotting and Pacing Speed. Rysdyk's Hambletonian 10 (Complete).* Pittsfield, Mass. Published by the author, 1897. 32 pp.

tory chapter, containing, among other things, a very complete description of Hambletonian, with measurements and his pedigree. The main body of the work is a list of all the descendants of Hambletonian that have trotted or paced in 2:10 or lower. The date of birth, best record, and the date when it was made are given for each horse, and also the name of each ancestor in the Hambletonian line with dates and records. The whole is cleverly arranged, so that, with the aid of the index, the entire pedigree of each horse can be traced easily as far as this particular line of descent is concerned. Following the list are a note on the transmission of acquired speed, remarks on the dual inheritance of the capacities for trotting and pacing, and several interesting tables.

Hambletonian was the sire of 1287 colts. The American Trotting Register Association's *Year Book* for 1896, from which Mr. Meston has gathered a large part of his facts, credits Hambletonian with being the sire of 40 trotters (records 2:17½ to 2:30), 148 stallions that have sired 1398 trotters and 155 pacers, and 80 mares that have foaled 104 trotters and 8 pacers. "At the close of 1896 the *Year Books* have listed altogether 12,945 trotters that have made records in 2:30 or lower and 4302 standard pacers, — a grand total of 16,207 trotters and pacers with standard records."

"It is safe to say," the author remarks, "that somewhere between 80 and 90 per cent of the whole number 'carry the blood' of Hambletonian 10."

In view of these facts, the ancestry of Hambletonian is of great interest. His descent is traced through three lines, one paternal and two maternal, back three and four generations, to Messenger, an English thoroughbred imported to Philadelphia in 1788. This horse is remarkable because of the trotting instinct which almost invariably appeared in his half-bred foals, and which was strongly transmitted by his thoroughbred sons. Moreover, the paternal grandam and maternal grandsire of Hambletonian were natural trotters, not related to Messenger nor to one another. It is not surprising, therefore, that Hambletonian should be the founder of a race of trotters. There are also a large number of pacers among his descendants, and it is a significant fact that there were a few pacers among the foals of his sire, Abdallah 1.

The intensity with which the instincts for trotting and pacing and the capacity for speed have been transmitted through the descendants of Hambletonian is shown by the fact that of the 54 trotters and 146 pacers of all breeds who have made records of 2:10 or lower, 50

trotters and 122 pacers trace their descent in one or more lines from this horse. The preponderance of pacers is accounted for by the greater swiftness of their gait. Because of the inherently greater speed of the pace over the trot, it will be necessary, in order to compare the speed attained by a pacer with the speed of his trotting ancestors or brothers, to establish some ratio by which a trotting record may be transmuted to its equivalent pacing record, in the same way that Galton has transmuted female stature into its male equivalent in his discussions of the statistics of human measurements. This will require the comparison of a large number of individuals.

In the meantime, wishing to gain some idea of what this ratio may be, we have compared the 54 best pacers with the 54 2:10 trotters. Comparing each horse of one class with the horse of the corresponding grade in the other, there is found to be an average difference of 2⅓ seconds, the maximum being 3¾ seconds and the minimum 1¾ seconds. It is interesting to note in this connection that in the case of one horse in our list that has made fast records in both classes the difference is not more than the above maximum, the pacing record of Jay-Eye-See being 2:06¼, and his trotting record 2:10. If this difference represents the gain in speed which a horse equally gifted in both gaits would make in pacing, then all horses who can trot within 2:12½ should be classed with the 2:10 pacers. At any rate, it is unfair to compare 2:10 trotters with 2:10 pacers, and for this reason the tables on pages 27 and 28 are misleading.

The author points out another source of error which arises from the introduction of the bicycle sulky with pneumatic tires in 1892. But, allowing for errors due to bicycle sulkies, improved tracks, and more experienced trainers, we can see a gradual increase of trotting and pacing speed in successive generations. How much of this improvement is due to the inherited effects of training, and how much to selection and combination of favorable variations in breeding? The list shows that a number of stallions and mares, after having been trained to fast records, have got foals that have made fast records. But there is no evidence that a line of trained ancestors is more successful in producing speed than a line of untrained ancestors, or a line of mixed trained and untrained ancestors. For example, of the 122 pacers in the list only 8 have a parent or grandparent that has paced in 2:10 or trotted in 2:13. None of the 50 trotters has a parent with a 2:10 record. In the list of trotters both parents are given in 22 cases. Both parents have a record in only 2 cases; in 13 cases one parent only has a record; and in 7 cases neither

parent has a record. This list of 7 fast trotters whose parents have no record is headed by Alix (2:03¾), and if extended would include Maud S., St. Julien, and Goldsmith Maid.

With only the lines of descent that happen to be traceable to Hambletonian, we have not sufficient data for any very extensive generalizations. But what we have indicates that variations in speed and their inheritance follow the same laws that Galton [1] has shown to apply to stature, color, and other fortuitous variations in man and other organisms. A horse in the 2:10 class is, as a rule, the single exceptional son or daughter of comparatively mediocre parents of good family. The largest number from any one parent is six, foals of Altamont, who has a wagon record of 2:26¾. But Altamont is a grandson of Abdallah 15, who was the sire of Goldsmith Maid (2:14), and who counts among his descendants Alix (2:03¾), Flying Jib (2:04), and John R. Gentry (2:00½). The importance of heredity in the production of speed is indicated very clearly by an examination of the pedigrees. Thus, Alix (2:03¾) is descended not only from Abdallah 15, but also by two lines from Harold, a son of Hambletonian, who is the sire of Maud S. (2:08¾). John R. Gentry (2:00½) and Joe Patchen, who paced this season in 2:01½, have a common ancestor by separate lines in George Wilkes; and Nancy Hanks is a granddaughter of Dictator, the sire of Jay-Eye-See, who has paced in 2:06¼ and trotted in 2:10. The author expresses very strongly the opinion, which seems to be borne out by the facts, that the capacities for pacing and for trotting are heritages which, like the light and dark colors of the eye,[2] are, as a rule, mutually exclusive, and that the development of either of these, as well as the capacity for speed, is dependent more upon selection of parents by the breeder than upon the education received by the foal from the trainer.

ZOOLOGY.

Weed's Life Histories of American Insects.[3] — This little work is evidently intended to meet in part the need of popular handbooks of nature study, and it does it in an admirable manner. It consists

[1] Francis Galton, *Natural Inheritance.*

[2] Galton, *loc. cit.*

[3] *Life Histories of American Insects*, by Clarence Moores Weed. New York, The Macmillan Company. 8vo, 272 pp., with illustrations. $1.50.

of a series of short essays on the life history of a number of our more common insects. The matter is handled in a simple and straightforward manner, and is well illustrated by figures in the text and by several full-page plates. Although largely a compilation, it is written by one who has done much original work in this field; hence the accuracy of its statements can be depended upon. While the entomologist will find in its pages comparatively little that is new, the amateur and the teacher who is trying to interest young people in what is going on around them will be able to gain much help from it.

J. H. C.

Weed's Stories of Insect Life.[1] — This book is similar in its purpose to the preceding, and resembles it in its method of treatment of the subject; but it is intended to be used by those who teach very young pupils. Such teachers will find it a helpful book.

J. H. C.

BOTANY.

North American Lemnaceæ.[2] — It cannot be doubted that the high character of the late Dr. George Engelmann's contributions to botany is largely due to the judicious concentration of his energies. No other American botanist of such wide general experience has so carefully restricted his published researches to the intensive examination of a few very difficult families and genera. Thus it was that Dr. Engelmann laid a sure foundation for a satisfactory classification of groups like Cactaceæ, Cuscuta, Juncus, Agave, Yucca, Lemnaceæ, and Alismaceæ. In consideration of this fact, the present director of the Missouri Botanical Garden could not have acted more wisely than in devoting so large a part of the present energies of his institution to the completion of work so well begun by his illustrious predecessor. Thus the recent reports of the Garden contain a series of valuable papers upon Yucca, Agave, Alismaceæ, etc., which, although based in part upon the collections and previous work of Engelmann, lose none of their originality on that account, but only

[1] *Stories of Insect Life*, by Clarence Moores Weed. Boston, Ginn and Company. 8vo, 54 pp., with illustrations.

[2] "A Revision of the American Lemnaceæ Occurring North of Mexico," by Charles Henry Thompson. Advance separate from the *Ninth Annual Report of the Missouri Botanical Garden*, issued Nov. 1, 1897. 8vo, 22 pp., 4 pll.

gain in worth in proportion as their originality begins at a higher plane and is built upon a surer foundation than could have been the case in other groups.

To this suite of useful papers Mr. C. H. Thompson has just added a revision of the North American Lemnaceæ. These diminutive aquatics, popularly called duck meats, include the most minute flowering plants. While from their peculiar structure they have long been familiar examples of such morphological phenomena as phylloidal stem, vegetative reproduction, reduction of floral structures, etc., their systematic interrelationship and geographic distribution have been, notwithstanding the critical treatises of Hegelmaier and Engelmann, but imperfectly understood. Mr. Thompson's paper is the first upon its peculiar field, since no previous monograph has at once covered and been restricted to North America.

While Engler in the *Natürlichen Pflanzenfamilien* reduces Wolffiella to a subgenus of Wolffia, Mr. Thompson follows Hegelmaier in recognizing four genera in the family, namely, Spirodela, Lemna, Wolffia, and Wolffiella, but rearranges them so that Wolffiella may stand next Lemna. No change is made in the North American Spirodela (represented by the common *S. polyrrhiza*), but a new South American species of somewhat doubtful identity and remarkably dissevered range is added to the genus. In Lemna the recognized North American species are *L. gibba*, *minor*, *trisulca*, *perpusilla* (with var. *trinervis*), *cyclostasa*, and *minima*. By the name *L. cyclostasa* (Ell.) Chev. is designated the plant which has for some years been known as *L. valdiviana* Phil., since the latter species, as the author believes, is identical with the *L. minor* var.? *cyclostasa* of Elliott's *Botany of South Carolina and Georgia*. It is a pleasure to see that the range of this species, unaccountably incomplete in Britton and Brown's *Flora*, is duly extended to the three southern New England states. In Wolffiella three North American species are recognized; namely, *W. floridana* (*Wolffia gladiata*, var. *floridana* J. D. Smith), *W. oblonga*, and *W. lingulata*. Of Wolffia there are also three species credited to the continent, — *W. papulifera* (a new species from Missouri, discovered by Bush), *W. punctata*, and *W. columbiana*.

Mr. Thompson's descriptions are clear and ample, and the copious outline illustrations, which are of his own drawing, are satisfactory. His observations upon the "resting stages" (Hegelmaier's *Wintersprosse*) are worthy of mention, and above all the careful citation of synonymy and enumeration of *exsiccati* make the paper a very welcome contribution to American systematic botany. B. L. R.

The Oxford Herbarium. — A little pamphlet of twenty pages,[1] prepared by Mr. Druce, the curator of the Fielding herbarium, gives some interesting statistics of the important collections of Oxford, which commence with a set of 300 specimens collected by the Italian, Gregory of Reggio, in 1606, and contain such historic herbaria as that of the Bobarts, Morison, Du Bois, Sherard, Shaw, and Sibthorp of the last century, and a host of more modern collections. While in an introduction to the pamphlet Professor Vines states that it cannot be hoped to accumulate at Oxford collections to rival those of Kew or of the British Museum, those already brought together are seen to number hundreds of thousands of sheets, and the aim is stated to be to render the Oxford herbarium as complete as possible in plants representing the flora of Europe and the adjacent Mediterranean region. T.

Botany at Geneva. — To the numerous publications devoted wholly or in part to botany which have clustered about the long-time home of the De Candolles is now added another, the *Annuaire du conservatoire et du jardin botanique de Genève*, edited by Dr. John Briquet, who also edits the excellent *Bulletin du laboratoire de botanique générale de l'université de Genève*. The new *Annuaire*, which appears as the official organ of the two botanical institutions of the city of Geneva, is intended to constitute each year a volume of from 130 to 250 pages, giving information as to the condition of the garden, progress made, and the growth and scientific utilization of the collections, as well as original articles based wholly or in part on the material of the conservatory and garden.

The first volume,[2] which has recently appeared, contains an interesting report on the garden and the Delessert herbarium for the year 1896, two seed lists, and the following scientific papers: Crépin, a revision of the roses of some old Swiss herbaria; Arvet-Touret, a revision of the Hieracia of the herbarium of the younger Haller; an account of new or little-known species of the same genus, chiefly of the Delessert herbarium; and a description and plate of Crepidopsis, a new genus of Mexican composites related to Hieracium (based on Pringle's No. 1654, of the year 1888); and Kränzlin, a description of two new species of Habenaria, respectively from Java and the Philippines. T.

[1] *An Account of the Herbarium of the University of Oxford.* Oxford, The Clarendon Press, 1897. Price, sixpence.

[2] *Annuaire du conservatoire et du jardin botanique de Genève.* 1re année. Genève, Georg et Cie., 1897. 143 pp., 1 pl. 5 francs.

GEOLOGY AND PHYSICAL GEOGRAPHY.

Recent Works. — A fifth edition of Hann, Hochstetter, and Pokorny's *Allgemeine Erdkunde* is in preparation; Part I, *Die Erde als Ganzes, ihre Atmosphäre und Hydrosphäre*, by J. Hann, of Vienna, having been issued last winter; Part II, *Die feste Erdrinde und ihre Formen*, by E. Brückner, of Berne, being just received; and Part III, *Pflanzen- und Tierverbreitung*, by A. Kirchhoff, being in preparation (Tempsky, Prag). The two parts now issued are distinct enlargements of the original work. They may be characterized as concise, thorough, and correct. There is, unfortunately, no work in English that can be compared to them in these respects. A teacher or student wishing a trustworthy book of reference cannot do better than place this work by his side.

The Library of Geographical Handbooks, edited by Professor Ratzel, includes no volume more noteworthy than the *Klimatologie* by Dr. Hann, the first edition having appeared in 1883, and then at once taking the position of a standard work of reference. A second edition is now issued in three volumes (Stuttgart, Engelhorn), the liberal increase in size permitting the addition of new data and the introduction of footnote references, which were wanting and greatly missed before. An earlier volume in the series was the *Morphologie der Erdoberfläche*, in two volumes, by Prof. A. Penck, of Vienna, which may be fairly characterized as the most important geographical handbook of recent years. It is particularly valuable in its brief historical reviews of the development of various topics and in its rich references to sources.

A. de Lapparent's *Leçons de Géographie Physique* (Paris, Masson, 1896) deserves mention, even if somewhat belated. It is written in a more readable style than the books above mentioned, and should not be measured by comparison with them, but rather on its own standard of attractive presentation. It is also notable as marking a distinct advance towards a rational, genetic treatment of land forms. The intending scientific visitor to Europe will find it of much value as a companion.

American teachers interested in the position of general geology in Europe will find a thorough presentation of the science in Prof. H. Credner's *Elemente der Geologie* which now appears in an eighth edition, twenty-five years after its first publication (Leipzig, Engelmann). It is a stout volume of 797 pages, of which the last 45 are devoted

to an index. The chief headings are petrographical, dynamic, structural, and historical geology, over half the volume being given to the last. Each chapter opens with a brief list of references to sources. Illustrations are numerous, those of fossils being the most elaborate.

The first volume of *La Face de la Terre*, a translation under the competent direction of E. de Margerie of Suess' famous *Antlitz der Erde*, is just received. (Colin, Paris. 835 pp., many figures.) There is no other book to which the advanced student can turn for so many applications of what he has learned in geology, for here is given a broad geological view of all explored lands. The asymmetrical structure of mountain ranges is the chief theme of this volume. The translators have added numerous supplementary paragraphs, indicated by brackets, and have brought the references to geological sources down to the present year. Any one wishing to strengthen his geological library in the direction of the structural geology of the world can hardly do better than order all the works here referred to.

Tarr's *First Book of Physical Geography* (Macmillan, 1897) follows his *Elementary Physical Geography* (1895). The second volume was prepared because many teachers who wish to give instruction in the "new physical geography" are unable to use the first volume; this statement revealing the peculiarly insufficient understanding of the subject that the teachers gained when they were scholars. The *First Book* attempts rather too much in its astronomical and geological chapters, and goes further into physics than is necessary in the pages on the atmosphere. It is at its best when presenting the features of the land; but here, as is often the case, it gives relatively greater prominence to process than to form, and as a result withdraws the chief attention of the student from the prime object of geographical study. It is, nevertheless, a valuable addition to our school literature, and might easily have been more valuable if a carelessness of style and statement here and there had been avoided.

SCIENTIFIC NEWS.

The German Society of Naturalists and Physicians will hold its meeting next year at Dusseldorf. Professor Waldeyer, of Berlin, will occupy the presidential chair.

Many readers may be interested to learn that the *Journal of the Boston Society of Medical Sciences* has been enlarged and is now the medium for the publication of the abstracts of work carried on in Harvard Medical School, the Biological Laboratories of the Massachusetts Institute of Technology, and the Massachusetts General and the Boston City Hospitals. The journal is issued ten times a year, and the subscription price is $2.00.

The British Museum has just acquired the collection of vertebrate fossils from the pliocene forest-beds of Norfolk, made by Mr. A. C. Savin. It contains about 1900 specimens, embracing many of the types of Newton, Adams, and Lankester.

Among the most interesting of recent items of news are the items concerning the expedition of the Sydney Geographical Society to the Ellice Islands to study the structure of a coral reef. The drill was sent down to 557 feet. Down to 487 feet the results were inconclusive, but beyond that point they strongly favor Darwin's theory; but the matter cannot be settled until a microscopic examination of the cores is made. The boring is being continued, and may be carried down to 1000 feet.

The Albany Museum at Grahamston, South Africa, is to have a new building two stories high, measuring 150 feet in length by 60 in breadth.

Professor Gundelfinger, of the Technical High School at Darmstadt, receives the gold medal for merit from the Academy of Sciences at Munich for his botanical researches.

At the session of the Académie des Sciences held at Paris, Dec. 13, 1897, the Cuvier Prize of 1500 francs was awarded to Prof. O. C. Marsh, of Yale University. This prize is "awarded every three years for the most remarkable work either on the Animal Kingdom or on Geology." The Cuvier Prize hitherto has been given to only

two persons in this country, Agassiz and Leidy. The former, however, was a native of Switzerland, where the special work was done for which his prize was awarded.

The collection of fossils made by Mr. W. E. Gurley, late state geologist of Illinois, is for sale. Besides duplicates and unclassified material, it contains over 14,000 specimens duly labeled.

René Sand has an interesting review of the marine zoological laboratories of the world in the October number of the *Revue de l'Université de Bruxelles.* He enumerates those of Ostend, Concarneau, Arcachon, Sebastopol, Naples, Roscoff, Wimereux, Penikese, Luc-sur-Mer, Trieste, Helder, Kristineberg, Villefranche, Solovetsky, Banyuls, St. Andrews, Granton, Tarbert, Puffin Island, Woods Holl, Misaki, Marseilles, Dunbar, le Portel, Plymouth, Copenhagen, Tamaris, Rovigno, Tatihou, Port Erin, Helgoland, Bergen, Jersey, False Bay, Tromsö, Drobak, Kiel, Flöderig, Millport, Liverpool, Bologna, Dieppe, les Sables d'Olonne, Santander, Cette, Messina, Alger, Newport, Palo Alto, and Cold Spring Harbor. The list includes those in operation as well as those abandoned, but fails to include the laboratories at Annisquam, Fort Wool, Beaufort, and the stations of the Johns Hopkins University in the West Indies.

During the past summer there have been a number of scientific expeditions sent out by various institutions. We have already alluded in these pages to the misfortunes of the zoological expedition sent by Columbia University to Puget Sound and Alaska, and the more disastrous Jamaica laboratory of the Johns Hopkins University. Columbia University also sent out an expedition for fossils to Colorado and Wyoming, under the direction of Prof. Henry F. Osborn, while a Princeton University party, under Prof. William Libby, visited New Mexico. New York University students, directed by Prof. Charles L. Bristol, made large collections in the Bermudas. The University of California sent an archæological expedition to the Santa Catalona Island, off the coast of southern California, while the ethnological party of the American Museum of New York, under the direction of Dr. Franz Boas, made large collections among the tribes of British Columbia. Cornell University had two parties in the field. One studied the geology of the Catskills, while another visited Colorado. A party of Stanford University students accompanied President Jordan to the Pribilov Islands and made large collections there, while others continued the work at Monterey. Prof. Frederick Starr, as a

representative of the University of Chicago, made ethnological studies and collections in Mexico, while the University of Pennsylvania had collectors at work in Peru. The Princeton expedition, under the charge of Mr. J. B. Thatcher, returned, after several years' stay in Patagonia, with abundant collections, and almost immediately Mr. Thatcher returned with another party to continue the explorations.

The British *Journal of Microscopy and Natural Science*, the organ of the Postal Microscopical Society, has been discontinued, after an existence of sixteen years, because of inadequate financial support.

Prof. Wesley Mills, of McGill University, has been granted leave of absence for a year, which he will spend abroad.

The Reale Accademia dei Lincei of Rome has elected Profs. B. Grassi and G. Fano to the section of zoology and morphology; Profs. H. Kronecker and O. Schmiedeberg, foreign associates in physiology; and Prof. A. Gaudry, foreign associate in geology and palæontology.

The thirteenth annual meeting of the Kansas Academy of Science was held October 27–29 at Baldwin, Kan., in the building of Baker University. Thirty-five communications were presented. Professor Williston, as president, gave an address on Science and Education.

The International Congress of Zoology meets in Cambridge, England, Aug. 23, 1898, under the presidency of Sir William Flower. All communications, requests for circulars, etc., should be addressed to the Local Secretaries, International Congress of Zoology, The Museums, Cambridge, England.

Dr. Rudolf Heidenhain, professor of physiology in the University of Breslau, died October 13, at the age of sixty-three. He was born in Marieneverder Jan. 29, 1834, studied at Berlin, Königsberg, and Halle, and was called in 1859 to the chair, which he held until his death. His work extended over all aspects of chemical and histological physiology, and was especially brilliant in its discourses relating to the action of glands, the effects of drugs, and upon lymph formation.

Dr. Andreas Petr. von Semenow has resigned his position as conservator of the zoological collections of the Academy of Sciences of St. Petersburg.

Adalbert Geheeb, the student of mosses, has removed to Freiburg, i. B. His address is 39, Göthestrasse.

Prof. A. de Lapparent, the mineralogist, has been elected a member of the Academy of Sciences of Paris.

Dr. O. F. von Möllendorf, the conchologist, has removed from Manila to Kowno, Russia.

Sir Frederick McCoy, professor of natural history in the University of Melbourne, has resigned.

Prof. Hans Molisch, of Prague, has gone to Buitenzorg, Java, for the winter.

Dr. Hugo de Vries has decided not to accept the call to the chair of botany at Würzburg left vacant by the death of Sachs.

Dr. O. Loew, of the botanical department of the University of Tokyo, has resigned on account of ill health.

We notice the following appointments and advancements of naturalists: Dr. Nikolaus von Adelung, of Geneva, conservator of the zoological collections of the Academy of Sciences of St. Petersburg. — Raphael Blanchard, professor of medical natural history in the medical faculty of Paris. — Dr. A. Borgert, privat docent in zoology in the University of Bonn. — Dr. William S. Carter, professor of physiology in the University of Texas. — Dr. Anton Collin, custodian of the zoological collections in the Natural History Museum in Berlin. — Dr. W. Detmer, full professor of botany in the University of Jena. — Karl Diener, extraordinary professor of geology in the University of Vienna. — Dr. Erwin von Esmarch, professor of hygiene and bacteriology in the University of Königsberg. — Dr. Max von Frey, of Leipzig, professor of physiology in the University of Zürich. — Dr. John Y. Graham, of Princeton, professor of biology in the University of Alabama. — Dr. H. F. Harris, professor of bacteriology in Jefferson Medical College. — Dr. B. Hatschek, of Prague, professor of zoology in the University of Vienna. — Dr. Robert Hegler, privat docent in botany in the University of Rostock. — Joaquin Gonzalez Hidalgo, professor of mineralogy in the University of Madrid. — Mr. H. Higgins, demonstrator of anatomy in the University of Cambridge. — Dr. Kaiser, privat docent in mineralogy in the University of Bonn. — J. Graham Kerr, demonstrator in animal morphology in the University of Cambridge, *vice* E. W. McBride. — Dr. Georg Kraus, professor of botany in the University of Halle. — Dr. R. von Lendenfeld, of Czernowitz, professor of zoology in the German University of Prague. — Dr. Felix Ritter von Luschan, assistant in the Natural History

Museum in Berlin. — Dr. S. C. Mahalanobis, demonstrator in physiology in University College of South Wales. — Dr. Heinrich Matiegka, privat docent in anthropology in the Bohemian University in Prague. — Dr. Hermann Munk, full professor of physiology in the University of Berlin. — Prof. Wladimir Iwanowitsch Palladin, director of the Botanical Gardens at Warsaw. — Louis V. Pirsson, of New Haven, professor of physical geology in Harvard University. — Dr. W. A. Rothert, of Kazan, professor extraordinarius of botany in the University of Charkoff. — Dr. Schöndorf, privat docent in physiology in the University of Bonn. — Dr. A. W. Shern, demonstrator in anatomy in University College of South Wales. — Dr. Spiro, privat docent in physiological chemistry in the University of Strasburg. — A. F. Walden, lecturer on natural science in New College, Oxford. — Prof. A. Fischer von Waldheim goes to St. Petersburg as director of the Botanical Gardens. — Dr. P. Zwaardemaker, professor of physiology in the University of Utrecht.

Recent deaths: William Archer, of Dublin, well known for his researches on Protozoa and the lower plants. — Dr. Leopold Auerbach, professor extraordinary of physiology in the University of Breslau. — Prof. Oskar Boer, bacteriologist, in Berlin, July 11, aged 54. — Samuel Brassai, naturalist, of Klausenburg, June 24, aged 100. — Dr. M. Euchler, editor of the *Entomologischer Zeitschrift*, in Guben, Prussia, in August. — Emil Fiek, author of the *Flora of Schleswick*, in Kunersdorf, June 21. — Nikolaus Golowkinsky, formerly professor of geology and mineralogy in the Universities of Kasan and Odessa, June 9, in the Crimea. —Georg Lieder, geologist, in Bogota, July 1, aged 35. — Rev. Andrew Matthews, English student of the microcoleoptera. — Sir Peter Le Page Renouf, archæologist and for several years a keeper in the British Museum, in October, aged 75. — Charles Stewart Roy, professor of pathology in the University of Cambridge, well known as a physiologist, Oct. 4, 1897, aged 43. — Dr. Emil Schmidt, teacher of zoology in the Berlin Gymnasia. — W. Wache, director of the Zoological Gardens in Lübeck, by suicide, July 19. — Dr. Hermann Welcker, formerly professor of anatomy in the University of Halle. — Charles Bygrave Wharton, ornithologist, in Totten, England.

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THE SIGNIFICANCE OF CERTAIN CHANGES IN THE TEMPORAL REGION OF THE PRIMITIVE REPTILIA.

E. C. CASE.

CERTAIN "mutations" or lines of definite evolution seem at the present time to be well established in the various mammalian phyla. Typical of such lines are the changes involved in the development of the Perissodactyla and Artiodactyla from the pentadactyl forms of the Eocene; the development of the complicated carnivorous and herbivorous molar teeth from the simple tritubercular type and the gradual assumption of the molariform condition by the premolars of the herbivorous forms. Around such persistent lines of development have gathered the minor changes or "variations" determining the various genera and species.

As yet there has been no recognition of such a line of definite evolution among the Reptilia, but it is the belief of the author that such a line can be demonstrated. The series of changes alluded to are those involved in the development of the temporal region of certain of the Permian Reptilia. Closely connected with this series are other changes, such as the gradual assumption of the tuberculate condition of the teeth and the introduction among the tarsal bones of a calcaneum.

The Pareiasauria Seeley (Cotylosauria Cope) are undoubtedly the most ancient of known Reptilia. The resemblance of these forms to the Amphibia demand that they be removed from union with the remaining Permian Reptilia in the group Anomodontia and considered as the ancestral form from which the Progano-sauria have been derived, not the reverse, as suggested by Haeckel. The most perfect form of this group known is *Pareia-saurus bombidens* O. The cranial characters in which this form resembles the Labyrinthodonta are thus summed up by Seeley (1). "The head shows five Labyrinthodont characters: (1) the form; (2) the sculpture of the cranial bones; (3) the arrangement of the bones that cover the head; (4) the presence of mucous canals between the orbits and nares; (5) the absence of the lachrymal bone from the anterior corner of the orbit of the eye." To this evidence may be added the presence of a cleithrum, figured by Seeley as an epiclavicle (2). The presence of a cleithrum in the Pareiasauria is confirmed by the evidence of an isolated scapula belonging to this group from the Texas Permian, now in the museum of the University of Chicago. To the upper end of this scapula is attached the distal end of an element that can only be a cleithrum.

From the Pareiasauria arose the Proganosauria by a series of changes involving the appearance of two fossæ in the temporal region. The first appeared between the squamosal-parietal and the prosquamosal-postorbital, the second and lower between the prosquamosal-postorbital and the quadratojugal-jugal. This resulted in the formation of two temporal arches, an upper, the postorbital, and a lower, the jugal.

In describing the quadrate of Pareiasaurus, Seeley says (2), page 325, "the quadrate bones are vertical, compressed, oblique plates, which extend outward and backward. They are five and one-half inches high, and in contact throughout with the external temporal shield." A figure of a quadrate is given by the same author (3), which he refers "to Pareiasaurus or a near ally"; this figure shows the characters mentioned above. The American forms of this group show the same form of elongated quadrate.

In Paleohatteria, one of the earliest of the Proganosauria, we find the same elongate quadrate. Changes in other regions of

the body, the tarsus, abdominal ossicles, and distal end of the humerus, gave rise to the Rhyncocephalia. The temporal regions of Proganosauria and Rhyncocephalia are very similar, the only difference being that in the first order the squamosal and prosquamosal are separate, while in *Sphenodon*, a typical rhyncocephalian, they are united. The condition of this region in the two forms is indicated in Fig. 1.

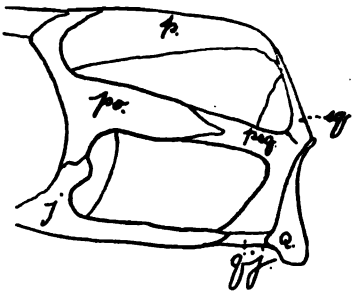


FIG. 1.—TEMPORAL REGION OF THE SKULL OF SPHENODON.

j, jugal; *p*, parietal; *po*, postorbital; *psq*, prosquamosal; *Q*, quadrate; *qj*, quadratojugal; *sq*, squamosal.

Before the development of the Rhyncocephalia, however, there appeared among the early Permian reptiles forms which exhibited the first steps in one of the most profound mutations of the reptilian line. These forms show a flattened form of quadrate instead of the elongated form of previous orders. It has been shown by Baur and the author (4) that the Pelycosauria of Cope are very similar in structure to the Rhyncocephalia, differing chiefly in the flattened quadrate. The difference in the temporal region of these forms from that of the Rhyncocephalia can be readily seen by comparing Fig. 2 with Fig. 1.

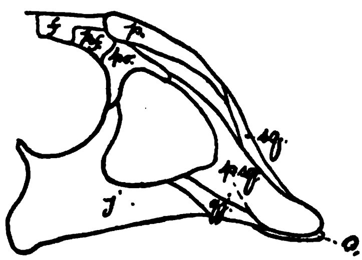


FIG. 2.—TEMPORAL REGION OF THE SKULL OF DIMETRODON.

f, frontal; *pof*, postfrontal. Other lettering same as in Fig. 1.

In the paper just cited, page 113, the authors stated that they considered the Pelycosauria "a specialized side branch of a line leading from the Proganosauria to the Rhyncocephalia." The author is now inclined to attach much greater importance to the appearance of the flattened quadrate at this point. The Pelycosauria and many of the Permian forms from South Africa and Russia all show this character of a depressed quadrate more or less completely surrounded by the supporting

bones. They seem to form a definite group, with this feature as the common point in their structure. The quadrate is not equally depressed in all forms, nor equally surrounded by the bones of the temporal region. Thus the ancestors of the Pelycosauria were in all probability forms lacking the elongate neural spines characteristic of this group, with the quadrate distinct from the surrounding elements and not so much depressed. These forms are as yet unknown. The Pelycosauria are no longer considered as a side branch of the main reptilian line, but as one member or branch of an equally divided line leading from the Proganosauria.

From this point onward the Reptilia are divided into two groups, one with an elongate quadrate which includes all modern and most extinct Reptilia, and one with a depressed quadrate reaching its highest development in the Permian, and in all probability losing its identity by almost imperceptible stages in the direct ancestors of the Mammalia.

Haeckel, in his *Systematische Phylogenie* (Vertebrata), page 299, has grouped the Permian forms under two orders, the Theriodontia (*Mastocephale theromoren*) and the Anomodontia (*Chelycephale theromoren*). In the first order he places the suborders Pareiasauria, Pelycosauria, and Palatosauria; in second the Dicynodontia and Udenodontia. If it be true that the Pareiasauria are a distinct order they must be dropped from this group. Then the remaining suborders, as defined by Haeckel, comprise the forms possessed of the depressed quadrate. It has been shown by Baur and Case (4) that the group Theromora does not exist, and it is now suggested that the forms with the depressed quadrate be referred to as the mastocephalous Reptilia, because of their evident culmination in the Mammalia, while the remaining Reptilia may be described as saurocephalous. In no known form, so far as I am aware, is there a tendency for a member of one of these groups to assume the form and condition of the quadrate characteristic of the other.

Leaving out of consideration the aberrant Dicynodontia and Udenodontia, a steady progress can be traced from the primitive pelycosaurian forms to the mammal-like forms. The quadrate of the early forms, while flattened and covered to a

considerable extent by the squamosal and prosquamosal bones, still shows to a considerable extent on the side of the skull; in the succeeding forms the quadrate is more and more reduced and the squamosal approaches more and more to an articulation with the lower jaw. Accompanying these changes are certain others, indicated below:

Pelycosauria: Quadrate depressed, appearing on side of skull. Teeth simple. Two well-developed arches.

Procolophonia: Quadrate depressed, nearly covered by the greatly enlarged quadratojugal (?). Teeth simple, reduced in number. Arches approximated only, a small foramen existing between the upper and lower.

Cynodontia: Quadrate covered by supporting bones. Teeth showing small lateral tubercles. Arches more closely approximated than in Procolophonia.

Lycosauria: Quadrate small, covered by supporting bones. Skull depressed. Teeth with well-developed tubercles. Arches united.

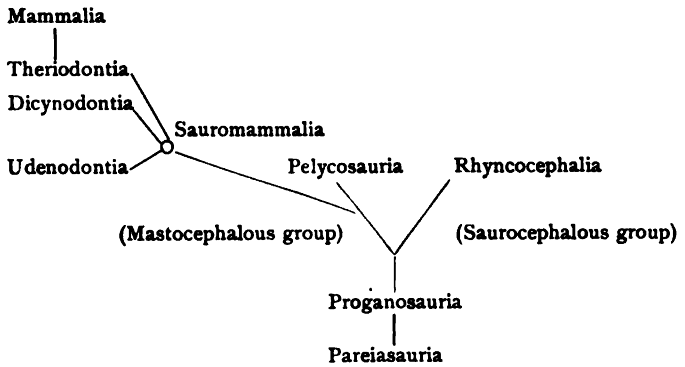
Gomphodontia: Quadrate very small, and inclosed in squamosal. Teeth tuberculate. Palate mammalian. Arches united.

The author was at one time undecided as to the nature of the arch in the Lycosauria and Cynodontia; in connection with Baur he said (4) that the mode of formation of the arch was uncertain. A specimen of *Cynognathus crateronotus*, figured by Seeley, shows an opening between the upper and lower arches which was uncertain in origin, there being some reason to suppose it to be the result of an injury to the specimen, but a study of the figure of Procolophon, given by Seeley, shows the same condition. The enormous quadratojugal (called squamosal by Leydekker) joins the jugal in front, which in turn joins a slender element by its anterior superior corner; this element runs backward, forming the lower and back portion of the orbit, and is undoubtedly the postorbital. Behind this element is another bone, the squamosal, or squamosal + prosquamosal, which rests upon the quadratojugal below; between all these elements is a small cavity, exactly as in Cynognathus. It is hardly probable that a break would occur in the same place in the two specimens, and so they are considered as showing the final stages of the union of the two arches to form the mam-

malian zygoma. This fact is further borne out by the very evident union of the two arches in Placodus and Cyamodus.

If this is true, the Theriodonta (Cynodonta + Lycosauria + Gomphodonta) cannot be the ancestors of the Squamata and Sauropterygia, as suggested by Cope (5). In these forms the history of the arches is very different. The Squamata possess only the superior temporal arch.

It is readily seen that the scheme here offered differs very little from that suggested by Baur in 1887 (6). The chief differences are the placing of the Pareiasauria as the most primitive group of the Reptilia, and the position of the mastocephalous Reptilia in opposition to all the remaining Reptilia, the changes in the quadrate region being the determinate feature in both groups. The following diagram will serve to make clear the ideas here expressed.



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STATE NORMAL SCHOOL, MILWAUKEE, WIS.

MANASSEH CUTLER.

JAMES ELLIS HUMPHREY.

A MAN who clearly deserves a distinguished place among American pioneers in science is the subject of this sketch. Without advantages of birth, and through life dependent on the meager stipend of a New England country minister, he yet contributed much useful work to the development of science and to the extension of civilization in the United States. Two volumes of extracts from his letters and journals, of the greatest interest and value, were published by some of his descendants at Cincinnati in 1888. These give a striking impression of his progressive spirit and tireless activity, and furnish the chief available facts concerning his life.

Manasseh Cutler was born May 3, 1742, the son of a farmer of Killingly, Conn. His home was evidently one in which the Puritan love of learning prevailed, for he was graduated at Yale in 1765. He then obtained a position as a teacher in Dedham, Mass., a somewhat unusual thing at the time when the towns about Boston were accustomed to look to Harvard for their teachers. Here he became acquainted with Miss Mary Balch, daughter of Rev. Thomas Balch, the minister at Dedham, and she became his wife in 1767. In that year he went to Edgartown, on Marthas Vineyard, to take charge of and close up the business of a relative of his wife, just deceased. While there he was admitted to the bar, having devoted his time since his graduation to reading law. But his first experiences in legal practice gave him a distaste for it, and he determined to enter the ministry.

Accordingly, he returned to Dedham and began a regular course of study with his father-in-law. The glimpses of his experiences and deliberations while preaching as a candidate in several Massachusetts parishes, afforded by his journal, show the shrewd and cautious man, with keen zest for amusing situations and with clear understanding of and sympathy with human

nature beneath the preacher's coat. Finally, in 1771, he accepted a call to Ipswich Hamlet, on Cape Ann, which was set off in 1793 as the new town of Hamilton. Here he remained fifty-two years, until his death, increasingly loved and respected, and the most influential man of the region. In his time the nearest place of importance was Salem, then at the height of her prosperity as a great shipping port. Mr. Cutler soon acquired a reputation there as a teacher, and received important additions to his slender salary for fitting the sons of many distinguished families for college, as well as for training in the theory of navigation many a young man who became a famous shipmaster in the East India trade. He never received from his parish more than four hundred and fifty dollars a year — then relatively a much larger sum than now, it is true.

During the Revolution the great need of army surgeons at the front called away the village doctor from Ipswich Hamlet, and the minister took it upon himself to study medicine, that his people might not be without help in sickness. At another time he served several months as a regimental chaplain in the Continental Army. It seems very likely that his medical studies first developed his interest in natural science; for we know that this branch of knowledge played no important part in college curricula in his day, and the first evidences of his attention to it date from this time. His interest in botany seems always to have predominated, and his chief publication was upon this subject. Yet he corresponded with many of the most distinguished scientific men of his time in both Europe and America on a great variety of the subjects then most discussed. Among these were the aurora borealis and other meteorological matters, physical problems, the habits and migrations of animals, as well as the plants of his own and other regions.

In June, 1780, he records having read Hales' *Vegetable Staticks* and his wish to follow out some lines of experimentation suggested to him by the reading. He evidently caught from it the inductive spirit, of which Hales' work was the first fruit in its field of research. The difficulties under which he labored may be understood from a letter written at this time to his friend, Professor Williams, of Harvard. He says: "I have

thought of several experiments which I fancy may be well worth making, but cannot well proceed without a barometer. I have a prospect of getting a tube soon, which you have been so kind as to offer to fill with the mercury. The scale I can get made in Salem if I could procure a barometer for a pattern; but there is none in that town. . . . If there is any gentleman of your acquaintance in Boston who has a barometer and makes little use of it, and would be so kind as to favor me with it until I can get one completed, I shall consider it as a very particular favor." A few months later he wrote to the Corporation of Harvard College for permission to take from the college library certain books which he had failed to procure in Europe, and which he had needed for the study of plants.

On January 31, 1781, the American Academy of Arts and Sciences held its first meeting for the transaction of business. It then elected officers and chose some new members, among them Mr. Cutler. Two years later he was made a member of the Committee on Communications in Natural Philosophy and Natural History, his associates being Theophilus Parsons and Gen. Benjamin Lincoln. He was one of the first party which visited the White Mountains for scientific observations, in July, 1784, and especially studied the plants of the region. Twenty years later he repeated the journey. In 1785 appeared the first volume of the *Memoirs of the American Academy*, which contains his chief published writing, "An Account of Some of the Vegetable Productions Naturally Growing in this Part of America, Botanically Arranged." This was the first connected account of any part of the flora of any American region by a native writer. The plants were arranged, of course, according to the Linnæan system, and there were many discriminating notes concerning the uses and peculiarities of various species. In the same year he was elected a member of the American Philosophical Society of Philadelphia. In the third volume of the *Memoirs of the American Academy* is a figure with brief "Remarks on a Vegetable and Animal Insect." This is an account of the larva of a stag beetle attacked by the *Clavaria militaris* of Linnæus, a fungus now known as *Cordyceps militaris*. It shows a clear understanding of the relations between

host and parasite quite free from that air of marvelousness which still pervades popular accounts of similar phenomena.

In July, 1787, Cutler went to New York to visit the expiring Continental Congress, and succeeded, largely by his personal influence, in securing favorable action on the proposed grant of land beyond the Alleghanies for settlement to a company in which he was interested. The evidence seems conclusive that his hand drafted at least that clause of the "Ordinance of 1787," for the government of the Northwest Territory, which forever excluded slavery from its limits, and which has been regarded as, in its effects, the most far-reaching single piece of legislation in the history of the country. Thence he went on to Philadelphia, where the constitutional convention was in session. While there he visited Dr. Franklin, then eighty-one years old. His embarrassment on meeting so famous a man and the way in which he was put at ease by Franklin's simplicity and cordiality, as well as the ill behavior of the great man's grandchildren, are all delightfully described in his journals. His accounts of this visit and of that to Carpenter's Hall mention especially the botanical books he saw. One morning he went with friends out to see Bartram's garden, on the Schuylkill, already falling into neglect. On the return journey to his home he stopped at Bordentown, N. J., to call on Michaux at his nursery there. He failed to find the owner, but saw his garden and recorded his impressions thus: "What could induce Mechard to fix down in this awful, gloomy, lonely, miserable spot is beyond my power to conceive. I was never more disappointed, and regretted the pains I had taken to see the ill taste and judgment of this botanical Frenchman."

In December of the same year a party left Mr. Cutler's house in Ipswich Hamlet with an ox-wagon bound for "Marietta on the Muskingum,"—the first settlers of the Northwest Territory. In the party were two of Mr. Cutler's sons. They arrived at their destination in the following April, and a few months later were visited by their father, who may fairly be called the father of the settlement. He had driven across the country in a chaise from his home, and returned in the same way after a stay of a few months. He prepared the charter of

Marietta College, and, while on the ground, made the first studies of the earthworks of the Ohio valley, computing their minimum age from the trees and remains of trees found growing on them. Some partly decayed stumps were found, between eight and nine feet across, on which it was impossible to count the annual rings. But he estimated a tulip tree, five feet and eleven inches in diameter within the bark, to be from four hundred and forty-one to four hundred and forty-five years old.

In 1789 his *alma mater* conferred on Mr. Cutler the degree of LL.D. Besides the societies already mentioned, he became a member of the Massachusetts Historical Society, the American Antiquarian Society, the New England Linnæan Society, and the Massachusetts Society for Promoting Agriculture; and he was made an honorary member of the Massachusetts Medical Society for his attainments in the healing art. He served as a member of Congress during two terms, from 1801 to 1805, as an uncompromising Federalist. His journals give a vivid idea of the intensity of political feeling in this first period of Democratic supremacy.

He had evidently planned an extended botanical work, and for many years collected notes and drawings with this in mind. They finally filled more than a dozen large volumes, which suffered much injury from a slight fire in his study during his temporary absence from the room. This occurred in the latter part of his life, and seems to have disheartened him. A part of these volumes were at one time in the possession of the late Prof. Edward Tuckerman, of Amherst College, who has said that the publication of the results of his studies would have given Dr. Cutler high rank as a botanist. In these manuscript volumes he recorded conclusions which were only given to the world when again reached by Bigelow, Nuttall, Gray, and others. For example, he recognized that the hickories are generically distinct from the walnuts, and indicated many new species first published by the authors already named. He was a great lover of plants from every point of view. His large garden contained a great variety, especially of trees and shrubs. He is said to have introduced into eastern Massachusetts the

buckthorn from England, the pawpaw, the persimmon, the tulip tree, the trumpet vine, and many more from farther west and south.

Dr. Cutler died July 28, 1823, and lies buried beneath a marble slab, on which, without fulsomeness of eulogy, a long epitaph recounts his many virtues and accomplishments. The writer made in 1896 a pious pilgrimage to the scene of his labors, still a sleepy little village, as he left it. There, all within a stone's throw, may still be seen the house where he lived, now enlarged and transformed, the church where he preached, remodeled since then, but still bare and uninviting, as in his day, and the old cemetery where he rests. Such an occasion makes one realize, as we do far too seldom, how much our modern science owes to men like Dr. Cutler. He has not left a great scientific reputation, it is true, though doubtless he might have done so under less adverse circumstances. But he did what he could. He was a pioneer in a new country, not merely a pioneer in science, but a pioneer for truth and civilization in every form, trying always to push back the limits of the intellectual and physical wildernesses of his time, and to clear the ground, not alone for cities and material gain, but with a view also to the upbuilding of sound learning and the enrichment of the world's knowledge, which material prosperity makes possible and ought to make certain.

THE WINGS OF INSECTS.

J. H. COMSTOCK AND J. G. NEEDHAM.

CHAPTER II.

The Venation of a Typical Insect Wing.

THERE are certain features of the venation of the wings of insects which occur in the more generalized forms of so large a proportion of the orders of this class that we are warranted in regarding them as typical of winged insects as a whole, and we are able to present a hypothetical type to which the wings of all orders may be referred.

This of course implies, what we believe to be the case, that all of the orders of winged insects have descended from a common winged ancestor. For it is not probable that had wings arisen more than once in this class that they should agree closely in their structural characteristics.

The recognition of the features of the wing venation that are common to the various orders of insects has been a matter of slow growth. Most writers on the subject have only attempted to work out the homologies of the principal veins within the limits of a single order; and thus have arisen the various systems of nomenclature of the wing-veins, which have done much to delay an appreciation of the uniformity of structure which really exists.

We will not take the space to trace out in detail the development of the idea that a uniform nomenclature of the wing-veins, based on homologies and, therefore, applicable to all orders, is possible. In 1870 Hagen attacked the problem in a paper, entitled "Ueber rationelle Benennung des Geäders in den Flügeln der Insekten."[1] But this essay apparently had little influence beyond calling attention to the importance of the subject. It was not till the appearance of the classic contribu-

[1] *Stettiner Entomologische Zeitung*, Bd. xxxi, pp. 316–320.

tion of Redtenbacher[1] that any great progress was made. This paper, with its numerous illustrations drawn from nearly all orders of winged insects, is really the starting point in the actual solution of the problem.

Unfortunately, however, Redtenbacher was misled by the erroneous theory of alternating convex and concave veins elaborated by Adolph.[2] The result was that, although Redtenbacher recognized the homologies of the main stems of the principal veins, he, in his efforts to apply this theory, was led into many serious errors.

Then Spuler[3] followed, and, basing his conclusions on a study of the tracheæ that precede the wing-veins, worked out the type of the lepidopterous wings. Unfortunately, Spuler overlooked the trachea that precedes the first of the principal veins, and began his numbering with the second principal vein, which he designated as vein I.

The next step in advance was made by the senior writer of the present series of articles. In a text-book of entomology[4] he worked out the homologies of the wing-veins in the Lepidoptera, Diptera, and Hymenoptera. In the preface of that book he said:

> The principal features of the method of notation of wing-veins, proposed by Josef Redtenbacher, have been adopted. But as the writer's views regarding the structure of the wings of primitive insects are very different from those of Redtenbacher, the nomenclature proposed in this book is to a great extent original. The chief point of difference arises from the belief by the present writer that veins IV and VI do not exist in the Lepidoptera, Diptera, and Hymenoptera; and that, in those orders where they do exist, they are secondary developments.

But again, unfortunately, the work was not carried far enough. While the non-existence of the concave veins IV

[1] Josef Redtenbacher, Vergleichende Studien über das Flügelgeäder der Insecten. *Ann. des. k. k. naturhist. Hofmuseums*, Bd. i, 1886, pp. 153–232.

[2] G. Ernst Adolph, Ueber Insectenflügel, 1879.

[3] A Spuler, Zur Phylogenie und Ontogenie des Flügelgeäders der Schmetterlinge. *Zeit. f. wiss. Zool.*, Bd. liii, 1892, pp. 597–646.

[4] J. H. and A. B. Comstock, *A Manual for the Study of Insects*. Ithaca, N. Y., 1895.

and VI of the Redtenbacher system was demonstrated for the orders named, no use was made of the wing venation in the other orders of insects; and his lack of definite knowledge on the subject made him willing to admit that these veins might exist as *secondary developments* in those orders with fan-like wings.

At last the time has come when we believe that we understand the homologies of the wing-veins in so large a proportion of the orders of insects that we are able to present a hypothetical type to which the wings of all orders may be referred. And this type includes not only the principal veins, but also the chief branches of these veins.

It should be borne in mind that our main object at this time is merely to trace the homologies of the wing-veins, to the end that a uniform nomenclature for all orders can be adopted, and also to enable us to make intelligent use in taxonomic work of the characters presented by them. We do not presume to say that we have definitely determined the peculiarities of the venation of the wings of the stem form from which winged insects have descended. We feel, however, that we have reached a sufficiently near approximation to this desired end to warrant our conclusions regarding the homologies of the wing-veins, and to enable us to commend a nomenclature for them which we believe can be accepted as final.

In designating the wing-veins they may be either named or numbered. The simplest method is, doubtless, to number them; and had the system which was proposed by Redtenbacher been based on a correct understanding of the primitive type, nothing better could be desired. But it was not; and, as several modifications of the Redtenbacher system are already in use, it seems doubtful if uniformity in numbering them could be soon brought about.

From the great mass of names that had been proposed for the principal wing-veins, Redtenbacher selected a set of terms, to the acceptance of which no objection has been urged. It seems, therefore, that the surest way to bring about uniformity of nomenclature is to give up the attempt to apply a set of numbers to the wing-veins, and to use the names adopted by

Redtenbacher. These names and the abbreviations of them, which we shall use in our text as well as in the figures illustrating it, are as follows:

Costa, *C.*	Media, *M.*
Subcosta, *Sc.*	Cubitus, *Cu.*
Radius, *R.*	Anal veins, *A.*

In designating the branches of the forked veins we have adopted the principle of numbering them proposed by Redtenbacher and combine the numbers with the abbreviations of the names of the veins. Thus, the first branch of radius is designated as *radius-one;* and for this term the abbreviation R_1 is used.

In numbering the branches of the forked veins, *the same number is applied to homologous branches throughout the series of orders.* It is only in this way that the greatest use can be made of the characters presented by the wings in working out the phylogeny of groups.

But, in carrying out this plan, we have found that in certain orders, as, for example, the Neuroptera, there is a marked tendency towards the multiplication of the branches of some of the principal veins. It results from this that we find, in each of these orders, branches that have no true homologues in other orders, although in some cases analogous branches exist. As these supernumerary veins do not concern us while we are discussing the venation of the typical wing, we will postpone the consideration of them.

It frequently happens that the branches of a forked vein are reduced in number by the coalescing of two or more branches. In numbering such a compound branch the coalescence is indicated by the term applied to it. Thus, in very many insects, the second and third branches of radius coalesce throughout their entire extent, forming a single branch; this we designate as *radius-two-plus-three,* writing the term thus, R_{2+3}.

We will postpone for a time the discussion of the nomenclature of the cross-veins and of the cells of the wing, and proceed to a consideration of the hypothetical type to which we have referred.

There can be no doubt that the veins of the fore wings and of the hind wings are homodynamous. Any one that studies the subject much is impressed by this fact. A single diagram will be sufficient, therefore, to represent the venation of both pairs of wings of this type. Fig. 4 is such a diagram.

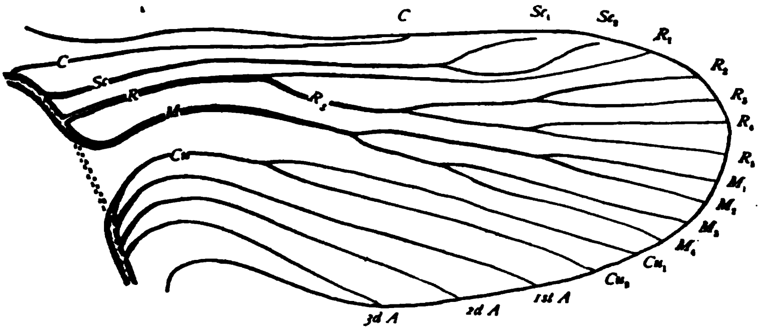

FIG. 4. — Hypothetical tracheation of a wing of the primitive nymph.

As the wing of a nymph is much more instructive than a wing of an adult for the purpose of determining homologies, we represent this ideal wing in that stage of development in which the forming veins appear as light-colored bands and the tracheæ as dark lines. This stage in the wings of an actual nymph is well shown by the half-tone reproductions of photographs of the wings of a nymph of Nemoura, given in Chapter I (Figs. 2, 3).[1] In our hypothetical type we have represented only the tracheæ, which precede the forming veins.

By representing the wing of a nymph we are able to represent the basal connections of the tracheæ that precede the veins, and thus show which are principal veins and which are branches of them. This point has received very careful attention, a large number of nymphs and pupæ, representing nearly all of the orders of insects, having been examined especially for this purpose. Fortunately, this evidence confirms the conclusions reached by various writers who have studied only the wing-veins of the adult, and merely serves to remove any doubt there might have been regarding these conclusions.

Another point which can be brought out in this way is the

[1] *American Naturalist*, January, 1898, vol. xxxii, pp. 46, 47.

distinction between principal veins and cross-veins. For, although in certain highly specialized wings, as, for example, those of the Odonata, every cross-vein is preceded by a trachea, we have found that, as a rule, the secondarily developed cross-veins are not preceded by tracheæ. The figures of Nemoura in Chapter I illustrate this.

In the adult the front, or costal margin, of the wing is usually strengthened by a vein or a vein-like structure; this is designated as the *costa*. A study of immature wings shows that, although the costa usually extends more or less nearly to the apex of the wing, the costal trachea is, as a rule, greatly reduced. This reduction of the costal trachea has led to its being overlooked by previous writers, and to a denial of its existence by Brauer and Redtenbacher.[1] It is true that Brongniart figures what he believed to be the costal trachea in the nymph of a dragon fly;[2] but the structure which he represents is evidently the edge of the wing within the wing sheath of the nymph.

We have succeeded in finding the costal trachea in nearly all of the orders of winged insects, and have found that in widely separated forms, as in many Hemiptera and in the more generalized Hymenoptera, it extends nearly or quite to the apex of the wing. Further details regarding it will be given in the treatment of the separate orders. It is only necessary to state here that we have abundant evidence to support the view that the costa of the primitive insect wing resembled the other wing-veins in being preceded by a trachea, and that the origin and course of this trachea was probably very nearly as represented by *C* in Fig. 4. In the photographs of the wings of a nymph of Nemoura, reproduced in Chapter I, the costal trachea is not evident; but figures will be given of other Plecoptera in which this trachea is as distinct as any and extends to the middle of the wing.

The second of the principal veins of the wing is designated as the *subcosta*. This extends more or less nearly parallel with the costa and but a short distance from it. In those orders

[1] *Zool. Anz.*, Bd. xi, 1888, pp. 443–447.

[2] *Rech. sur les Insectes Fossiles*, Pl. viii, Fig. 1, *a*.

where there are many wing-veins it gives off numerous small branches to the costa; in the orders where there are few wing-veins it appears in the adult to be an unbranched vein. But a study of the subcostal trachea in nymphs and in pupæ shows that it is forked in at least several widely separated orders; we have, therefore, represented it so in our type (Fig. 4, Sc_1 and Sc_2). In adult wings the branches of the subcosta are usually either wanting or appear as cross-veins. In those orders in which the wing is corrugated the subcosta lies at the bottom of a furrow, which stiffens the costal edge of the wing.

The third vein is the *radius*. This is the most prominent vein in the wing; and it is the one which, from the great variety of its modifications, offers more often than any other vein obvious characters of use in taxonomic work. In spite of the wide differences of form of this vein in the different orders, it is now clear to us that these various forms have all been derived from a type which still exists, but slightly modified, in the more generalized Trichoptera, Mecaptera, Diptera, and Lepidoptera, and in certain genera of several other orders. In its typical form this vein is five-branched (Fig. 4, R_1–R_5). The main stem of the vein separates into two divisions; the first of these is simple and is more or less nearly a direct continuation of the main stem — this is *radius-one* (R_1); the second of the principal divisions of radius is typically four-branched, and on account of the frequency of the necessity of making reference to it a special name has been applied to it, the *radial sector* (R_s). The radial sector separates into two divisions (R_{2+3} and R_{4+5}); and each of these again separates into two divisions, the former into *radius-two* (R_2) and *radius-three* (R_3), and the latter into *radius-four* (R_4) and *radius-five* (R_5).

The vein occupying the center of the wing is the *media* (M). In those orders in which it retains most nearly its primitive form it is usually three-branched; but the fact that in the more generalized members of several widely separated orders it is four-branched leads us to believe that it was four-branched in the stem form of winged insects. The branches are designated as *media-one* (M_1), *media-two* (M_2), *media-three* (M_3) and *media-four* (M_4), respectively.

The fifth principal vein is the *cubitus* (*Cu*); this vein separates into two branches, —*cubitus-one* (Cu_1) and *cubitus-two* (Cu_2).

Between the cubitus and the anal margin of the wing there are typically three veins; these are commonly termed the anal veins. We will distinguish them as the *first anal* (*1stA*), the *second anal* (*2dA*), and the *third anal* (*3dA*), respectively, the first anal being the one nearest to the cubitus.

The first anal vein is generally simple; but in those orders where the anal area of the wing is expanded the second and third anal veins become separated into many branches, which form the supports of the fan-like portion of the wing.

Before leaving the discussion of this hypothetical type it seems necessary to say a little regarding the basal connections of the tracheæ that precede the wing-veins. In what appears to us to be the most generalized type, the tracheæ that supply the wing with air arise from two distinct trunks, as shown in Fig. 4. The first of these trunks is a branch of the dorsal longitudinal trachea of the thorax; the second, of the ventral longitudinal trachea. This type exists in all Plecoptera that we have examined and in certain cockroaches; we have not found it elsewhere.

The two groups of wing-tracheæ thus formed may be designated as the *costo-radial group* and the *cubito-anal group*, respectively. When the two groups are distinct, the trachea that precedes the media is a member of the the costo-radial group.

In most insects there has been developed a transverse trachea connecting these two groups of tracheæ; the position of this *transverse basal trachea* of the wing is indicated in the figure by dotted lines. Frequently the transverse basal trachea is indistinguishable from the two main trunks which it connects, the three forming a single, continuous, transverse trachea, from which arise all of the wing tracheæ. All of the stages of this development have been found by us within the Orthoptera.

When a transverse basal trachea is formed, the medial trachea (*i.e.*, the trachea that precedes media) tends to migrate along it towards the cubito-anal group of tracheæ, and often becomes united with that group. This is well shown in certain Orthoptera and in the Hemiptera. In some cases the base of

the radial trachea tends to follow the base of the medial in its migration along the transverse basal trachea towards the cubito-anal group (Acrididæ).

We have found no indication that the formation of a transverse basal trachea and the subsequent migration along it of the base of the medial trachea is influenced at all by the flight function of the wing, as the arrangement of the wing-veins does not appear to be modified by it. It should be remembered that the transverse basal trachea and the bases of the wing tracheæ are within the thorax of the adult insect, and are thus beyond the influence of the migrations of the wing-veins.

It is probable that these changes have to do with improving the air supply of the wing; but we have not sufficient data, as yet, to warrant a definite statement on this point. The important thing for the purposes of the present discussion is that one must know of this tendency on the part of the medial trachea to migrate along the transverse basal trachea in order to be able to recognize it in its various positions.

Entomological Laboratory,
Cornell University, December, 1897.

THE DAILY AND SEASONAL ACTIVITY OF A HIVE OF BEES.

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Not long ago there was performed a series of experiments with a hive of bees by a French bee keeper, M. Leon Dufour, and published in one of the French apicultural journals, which is of considerable biological interest, showing, as it does, the relation of the activities of bees to the various conditions of honey flow, number of bees, season, etc. Although hives have been frequently weighed to show the daily increment of honey, this was the first attempt to find out what more might be learned by weighing. An hourly record of the weight of the hive used in the experiments was kept each day through the whole season. From the data obtained it was possible to plot daily and seasonal curves, some of which are here reproduced. Although the most was not made of the facts learned in making comparisons, enough was done to bring out the relations between the activity of the bees and the flow of nectar during the day, and the season, as well as the relation between the daily amount of nectar collected and the number of bees in the hive, and between the number of bees and the different seasons. The series of hourly weights also shows the rate at which the bees leave the hive, and when the number returning exceeds those departing. The facts learned by the experimenter might be carried further and comparisons made with hourly, daily, or seasonal changes of weather, and with the floral calendar of any particular locality, and it is with the hope that further experiments may be performed and carried out with greater detail that the account of Dufour's experiments is given here.

In these experiments the first morning weight was taken as the zero point for the day. As is evident in the curves reproduced in the figures, this weight was made sometimes at 5 A.M. and sometimes at 5.30, and sometimes later. The general

results, however, remain essentially the same. On May 8 this weight was taken at 5 A.M., and, as shown by the curve (Fig. 1), the weight of the hive slightly decreased during the next hour, or, in other words, the bees left it for their field labors in small numbers, but at 6 o'clock large numbers of the bees left, for during the succeeding hour the weight of the hive decreased by about 300 gm. From 7 o'clock until 8 the number of outgoing bees seemed to decrease, for the line of descent, as shown in the figure, is not quite so precipitous. This change, however, might and probably was due to returning bees. This brings out the crudity of the method of experimentation; for the curves, without an actual counting of bees, can show only relative numbers. This, however, is sufficient for practical purposes. At 8 o'clock the hive was over 500 gm. lighter than in the morning, and from this time until 9 it decreased in weight but little, reaching then the minimum forenoon weight of— 550 gm. From 9 o'clock until 10 the hive very slowly increased in weight, and then more rapidly, until at the end of the next hour the weight had risen to 380 gm. below the zero weight. Then it as rapidly decreased until noon, after which it slowly sank to 620 gm. below the morning weight,—the second minimum and

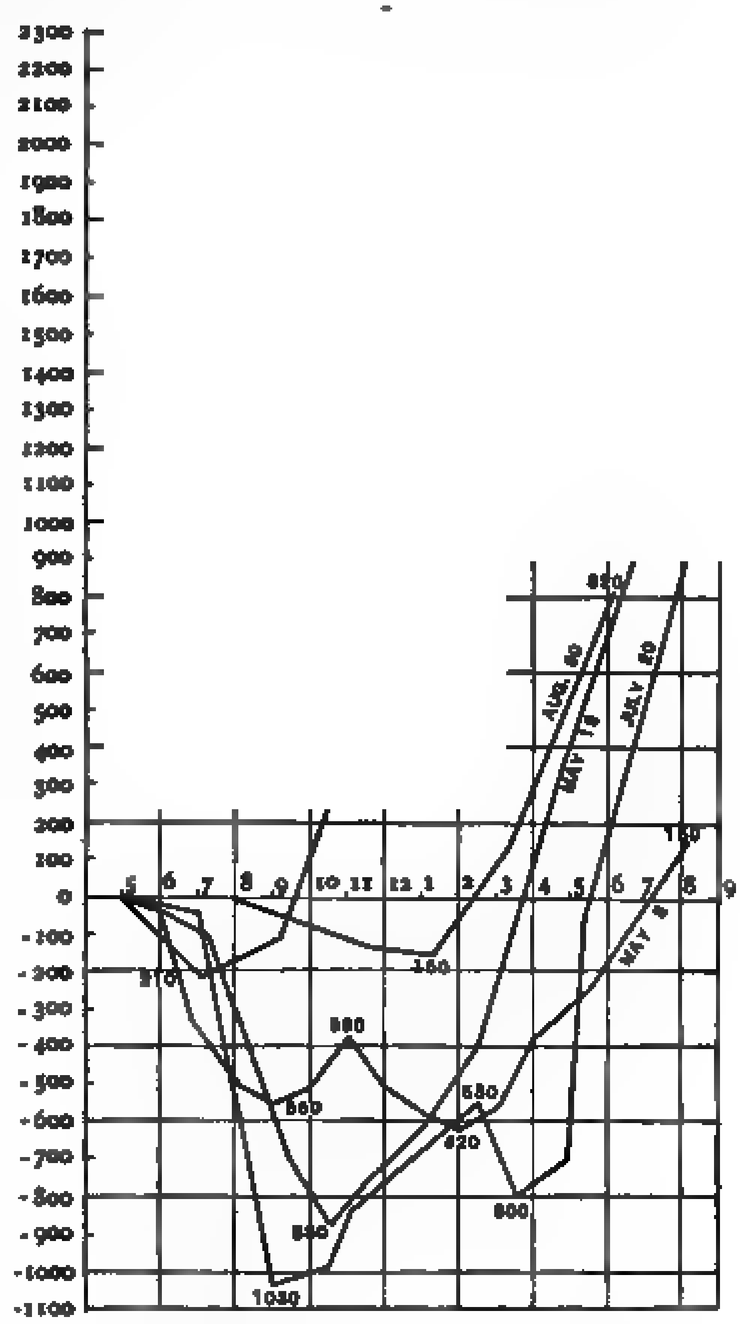

FIG. 1. —The horizontal lines show the weights in grams above and below the zero line (= the first morning weight). The vertical lines represent time.

the lowest for the day. From this time on the bees returned in large numbers evidently, and the hive consequently rose in weight, so that it passed the zero line at 7 o'clock, and reached 150 gm. above the morning weight one hour later, when the weighing was discontinued. This 150 gm. of course represents the amount of stores secured during the day.

The most remarkable feature of this curve is the sharp rise just before noon, thus making two points of minimum weight for the day. Several suggestions might be made to explain this peculiarity. Directly, it is certainly due to a large number of bees returning at about the same time. The small amount of honey gathered and stored during the day seems to indicate some relation with the nectar flow, which evidently was not great. Dufour, basing his remarks on experiments by Bonnier, explains the matter by pointing out that the flow of nectar varies during the day, and has a forenoon and an afternoon maximum flow, with an intervening period of small flow. According to these experiments, the nectar flows freely during the cooler portions of the day and much less so during the period of greatest heat, which ordinarily comes somewhat after midday. Of this change in the nectar flow the bees take advantage, and the peculiar curve which has been described is a result. This explanation is not, however, sufficient to account for the rise in this particular curve at 11 o'clock, for the reason that, as noted above, the hottest part of the day does not ordinarily occur in the forenoon. It seems, however, to explain the curve of July 20, where the intermediate rise reaches its maximum at 2.30. The difference between the two curves in respect to this rise may doubtless be explained by the difference in the total flow of nectar, which a comparison of the two curves shows to have been very much greater on July 20. The flow being small on May 8, it would consequently soon be exhausted, causing the bees to return earlier than they would have done had it been more abundant.

By May 18 conditions had evidently very materially changed. During the first one and one-half hours the bees left the hive slowly, although somewhat more rapidly than during the corresponding time on May 8. From a little after 7 o'clock they left

in large numbers, so that the weight of the hive sank rapidly to 880 gm. below the morning weight. From this time (10.30) the weight of the hive rose with almost as great rapidity as it had decreased, and passed the zero mark a little before 4 o'clock. It continued to rise until 8 P.M., when the record shows that 1320 gm. of stores had been added during the day.

The striking feature of this curve is the absence of the intermediate rise forming so strong a feature in the curve of May 8. But the difference seems explainable by the greater flow of nectar, evidently close at hand, which enabled the bees to quickly secure and return with their loads. The short flow of the middle of the day must certainly have been relatively very much more abundant than the aggregate power of the small laborers to dispose of it.

In the other curves there is shown some slowness in starting to work in the morning. On June 4 (Fig. 1) the decrease in weight was comparatively rapid and continued at the same rate at which it began. At 7 o'clock, or two hours from the first weight, the hive began to increase somewhat slowly in weight until a little past 9. Then it increased rapidly and crossed the zero line about half an hour later. By 8 P.M. 4550 gm. had been added to the morning weight of the hive.

The curve for July 20 is remarkable for the great decrease in weight, 1030 gm., and for the rapidity of the decrease, reaching, as it did, the limit at 9 A.M. Unlike the first minimum of May 8, this is the lowest of the two for the day. The reason for the difference is doubtless to be found in the greater flow of nectar on the latter day, as shown by the 990 gm. of stores added for the day. Finally, the very precipitous rise in weight, from about 700 gm. at 5 to about 60 below the morning weight, during the next 20 minutes seems somewhat remarkable.

If, now, the amount of stores be poor, it is evident that the different periods of strong honey flow for the season may be contrasted readily with the seasons of poor honey flow and with the blooming time of different species of nectar-bearing plants. In connection with what Dufour tells his readers, the curves here reproduced show two periods of good honey flow and two of poor honey flow. The first of the latter periods

began the season. It was followed by a period of good honey flow, extending from the latter part of May through June, and was due mostly to the blooming of acacias, which were evidently close at hand. The greater part of the summer was occupied by the second of the two periods of relatively poor honey flow, and was succeeded by the second of the other periods, beginning in the latter part of August and continuing into September. This, Dufour informs us, was mostly due to heather bloom.

A further comparison is to be made which brings out the relation of the number of bees in the hive to the different portions of the season. To make this comparison somewhat more accurate, curves are chosen (Fig. 2) that show almost the same amount of added stores for the day. On May 11 the workers were evidently numerous, since the hive decreased in weight by 730 gm., and if 10 bees be allowed to a gram there must have been more than 7300 bees at work. By July 18 they had increased greatly, so that, as shown by the minimum weight of 1510 gm. for the day, there were evidently more than 15,100 workers that left the hive, which is more than twice as many as on May 11. In August, as shown by the curve for August 21 and that for August 30 (Fig. 1), there were very few bees — on the former date only about 2000 that went to work. At first glance the curve for June 4 seems to show the same dearth of workers, but on May 18 they were relatively numerous, and, since it is scarcely possible that the workers had died off in great numbers between the two dates, the

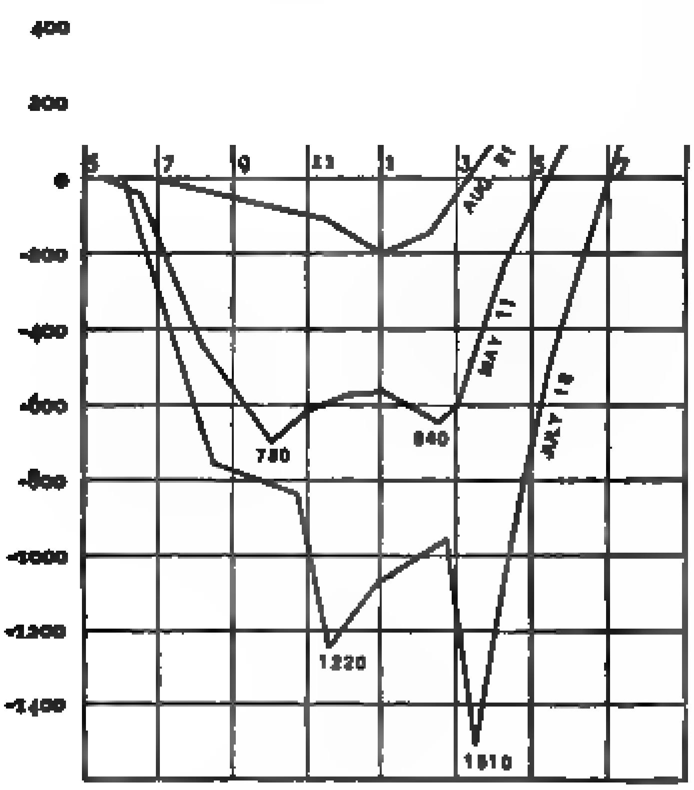

FIG. 2. — These curves are compared to show the differences in the number of bees in the hive.

small decrease in weight on June 4 seems to be more correctly attributed to the fact that the bees secured their stores so near by and returned so frequently and in such numbers that a very small (210 gm.) instead of a great decrease in weight resulted. The same explanation, also, may account for the curve crossing the zero line during the forenoon.

From the data that have been given one may conclude

1. That for the particular locality, Fontainebleau, where the weights were taken, there are four periods of honey flow, two characterized by an abundant and two by a poor flow, and that the activity of the bees through the abundant flow and that during the poor flow is characteristic in each case. During the poor flow there is a period of comparative inactivity during the middle of the day, corresponding apparently to a period of small flow of nectar, but during the abundant flow the activity of the bees is more or less constant through the whole day.

2. Aside from this midday activity the bees go and come steadily, and the hive, after the minimum weight is passed, increases in weight progressively and with comparative steadiness.

3. When the flow of nectar is poor, or comparatively so, the bees during the first hour or so leave the hive slowly. At the end of this time the rate of departure changes to a very rapid one, which continues with slight variation until the minimum weight is reached.

4. When the flow of nectar is abundant the rate of departure continues, as at the start, to be practically the same until the minimum is reached ; but this feature of the curve may be due also to the greater number of bees returning to the hive and the unloading of heavy loads more than to the bees maintaining a constant rate of departure.

5. When the flow is very abundant the outgoing bees do not reduce the weight of the hive to so great an extent as when the flow is relatively poor.

THE FIRST ANNUAL MEETING OF THE SOCIETY FOR PLANT MORPHOLOGY AND PHYSIOLOGY.

ERWIN F. SMITH.

For some years a move has been on foot to organize in the eastern United States a society for the study of the living plant, *i.e.*, to include all who are actively engaged in botanical studies not purely floristic. The plan was outlined at the meeting of the American Society of Naturalists in Philadelphia in 1895, but not enough botanists were present at that meeting to warrant any attempt at organization. A committee was, however, appointed, with Dr. James E. Humphrey as chairman. This committee reported at the Boston meeting of the American Society of Naturalists, whereupon the botanists present resolved to continue the agitation, and Dr. W. F. Ganong was authorized to see what could be done in 1897 at the Ithaca meeting of the American Society of Naturalists, with which body it was considered best to affiliate. After considerable correspondence, it was decided to call a preliminary meeting and determine wholly by its success or failure whether or not a society should be organized. A meeting was therefore called at Ithaca, N.Y., December 28 and 29. About thirty botanists were present, and much interest was manifested in the proposed new society. Thirty papers were listed on the program, and many of them were of unusual interest. It was therefore decided to complete the organization, which was done by the adoption of by-laws and the election of officers for the ensuing year. It was decided not to meet farther west than Buffalo or south than Washington; and, while it is believed that the bulk of the membership will naturally be drawn from the territory wherein the sessions are held, no geographical restriction was placed on membership. It was also decided that the society has no *raison d'être* unless it actually stands for what its title expresses, the purely floristic

work of the country having already ample outlet for its energies. Two standing committees were appointed, one on admissions and the other on programs. Abstracts of papers designed to be read before the society must be in the hands of the program committee, of which the Secretary-Treasurer is chairman, on or before December 1. No one shall be admitted to the society who has not published valuable papers or given satisfactory evidence of ability to do original work. For the present, at least, the society will meet with the American Society of Naturalists. Dr. W. G. Farlow was made President for 1898, and Prof. W. F. Ganong, Secretary-Treasurer. No proceedings will be published. The following new members were elected: Spalding, Webber, Swingle, Rowlee, Harshberger, Fairchild, Harper, Holm, Woods, Hicks, Pieters, Merrow, Porter. The old members, *i.e.*, the original committee, and such persons as were subsequently invited to become members of it, include Farlow, Goodale, Bailey, Atkinson, Smith, Galloway, Burt, Wilson, Sturgis, Richards, Cummings, Macfarlane, Thaxter, Penhallow, Robinson, Greenman, Stone, and Ganong. It is hoped that the end of the year will see the membership of the society increased to at least forty, and it is confidently believed that the ensuing meetings will be even more successful than the pleasant one which has just closed.

The following is a synopsis of the proceedings. In most cases the abstracts were made at my request by the authors themselves:

PROF. JOHN M. MACFARLANE: *A Mycorhiza in the Roots of the Liliaceous Genus Philesia.* This was the second recorded case of symbiosis between a liliaceous plant and a fungus. The genus Philesia grows in the damp humus soil of West Patagonia, and forms coralloid root masses. The fungus was sparingly present outside the roots, also in the epidermis and exocortex, but formed an abundant growth in the mesocortex, the cells of which rapidly became filled with coiled fungous hyphæ. The large spherical starch grains of these cells were acted on by the hyphæ, and were dissolved by solution rather than corrosion. A large amount of proteid material then appeared in the hyphæ. With growth of the root extremity the fungus steadily penetrated the mesocortex cells of the growing point, numerous hyphæ

being observed in the tenth to twelfth zone of cells behind the apex. Invariably the crystal cells were left untouched.

The close similarity of the above to cases recorded by Groom for Thismia, and by other authors, was referred to, but the conclusion was reached that, while the fungus might for many generations aid the host in the elaboration of protein compounds that were absorbed by the latter, ultimately, though very gradually, the fungus would prove a destructive agent.

PROF. GEO. F. ATKINSON: *Studies on Some Mycelium and Fungi from a Coal Mine.* On the 14th of September the speaker explored abandoned portions of the Algonquin coal mine near Wilkesbarre, Pa., for the purpose of studying the mycelial formations on the doors in the gangways and on the wood props which are used to support weak places in the roof above. Several flashlight photographs were made of the remarkable displays of the mycelium, some four hundred feet below the surface, and of some of the fruit forms. Mature fruit collected has been determined as follows: *Polyporus versicolor, P. annosus, Coprinus micaceus, Stropharia sp., Hymenochæte sp., Merulius sp.*, etc. The paper was illustrated with lantern views. Some of the mycelial growths entirely covered areas one to two meters square, and were astonishingly luxuriant.

E. A. BURT: *Is there a Basidiomycetous Stage in the Life History of Some Ascomycetes?* The author described cases of close association of *Graphium giganteum* (Pk.), also known as *Dacryopsis ellisiana* (Berk.) Massee, with the discomycete *Lecanidion leptospermum* (Pk.), also known as *Holwaya tiliacea*, E. and E., and believes them to be different stages of the same plant. *Dacryopsis ellisiana* was described as a basidiomycete, and its hymenium and basidia figured by Massee in *Journal of Mycology*, 6: 181. The present study is being carried on, therefore, to decide whether *D. ellisiana* is a basidiomycetous stage of the ascomycete already named. If it is such a stage, the fact will have great significance in determining the relationship to each other of the great classes of fungi, basidiomycetes and ascomycetes.

Specimens of the Dacryopsis collected in August, October, November, and December show only conidial condition, and no true basidia and basidiospores. The conclusion is reached that, until further study demonstrates the presence of basidia, *Graphium giganteum* (Pk.), or *Dacryopsis ellisiana* (Berk.) Massee, should be regarded as a conidial rather than a basidiomycetous stage of the ascomycete *Lecanidion leptospermum* (Pk.).

David G. Fairchild: *Basidiobolus, a Fungus Derivative of the Conjugatæ.* Read by title.

Dr. G. E. Stone: *The Conjugation of Spirogyra.* Read by title.

Dr. G. E. Stone: *Chemotropism in the Peronosporeæ.* Read by title.

Dr. Erwin F. Smith: *Additional Notes on the Bacterial Brown Rot of Cabbages.* Field studies of this disease were made in Michigan, Wisconsin, Ohio, and New York in August, September, and October of 1897. These served to confirm the earlier published statements of the writer[1] respecting the manner of infection and the usual symptoms. A number of new facts which appear to have an important economic bearing were also brought to light. Some of these discoveries are as follows: (1) this disease is serious in many parts of the United States; (2) the greater part of the infections take place through natural openings of the plant, *i.e.*, through water pores located on the serratures of the leaves; (3) the disease is frequently disseminated by insects; (4) the wild mustard, *Brassica sinapistrum*, is one of the common host plants; (5) the disease is very frequently disseminated by man, *i.e.*, by making seed beds on infected soil, and transplanting the germs in infected seedlings to land previously free from it; (6) when a soil has once become infected, there is reason to believe that the germs are capable of living in it for a series of years and will attack cabbages which are planted on it; (7) the disease may be restricted by planting seed beds on healthy soil; by transplanting, as far as possible, to sod land, or at least to land not previously occupied by crucifers; by destroying wild mustards and parasitic insects; by removing badly affected plants bodily; and, in early stages of the disease, *i.e.*, when the disease has only recently passed out of the water-pore stage of infection, by removing affected leaves. A full account of the economic aspects of this disease has been published by the Department of Agriculture in the shape of a *Farmers' Bulletin*, which may be had on application. Cultures of the parasite and dried leaves and stems of cabbage showing the characteristic symptoms were passed around.

Dr. Erwin F. Smith: *Occurrence of Kramer's Bacterial Disease on Sugar Beets in the United States.* Attention was called to the existence in parts of the United States (Michigan, Wisconsin, etc.) of a disease of sugar beets much resembling, if not identical with, that

[1] *Science*, June 18, 1897, p. 963, and *Centralb. f. Bakt.*, 2 Abt., July 7, 1897, p. 284.

described by Kramer and Sorauer in 1891–92, and more recently by Busse.[1] The root shrivels in places, becomes very black, and finally breaks down here and there with the formation of a sticky exudate composed of bacteria. Cultures from the interior of blackened roots remained sterile. Cultures from the syrupy exudate yielded an organism resembling, so far as tested, that described by Busse as the cause of the disease. It is yet too early, however, to say whether the organism isolated is identical with *Bacillus betæ* Busse, or whether it is in any sense a true parasite. It appears worth mentioning in as much as it seems to be rather common, and destroys cane sugar and grape sugar with the formation of hydrogen, carbon dioxide, and an acid. Possibly this is one of the organisms which has given trouble to the chemists in sugar diffusion work, inverting the cane sugar and liberating gases (see *Journ. Soc. Chem. Ind.*, vol. xiv, p. 876). Cultures on steamed and raw beets, on steamed potato, and in fermentation tubes were exhibited. On steamed slices of sugar beet there is a copious production of gas, which, owing to the viscidity of the bacterial layer, remains for a considerable time imprisoned in little blisters.

DR. W. C. STURGIS: *On Some Aspects of Vegetable Pathology and the Conditions which Influence the Spread of Plant Diseases.* Paper withdrawn.

O. F. COOK and DAVID G. FAIRCHILD: *Fungus Gardening as Practiced by the Termites.* Read by title.

DR. W. P. WILSON: *On the Possibility of Securing Botanical and Other Material for Original Research through the Philadelphia Museums.* Read by title.

H. J. WEBBER: *Are Blepharoplasts Distinct from Centrosomes?* After discussing our present understanding of the structure and functions of the centrosome, the speaker pointed out that blepharoplasts are special organs of the spermatic cells of Zamia and Ginkgo, which, in certain stages of their development, somewhat resemble centrosomes. The presence of similar organs in the spermatic cells of certain Filicineæ and Equisetineæ have also been recently described by Belajeff. In Zamia and Ginkgo the blepharoplasts arise *de novo* in the cytoplasm of the generative cells and are located on opposite sides of the nucleus, about midway between the nuclear membrane and cell wall. They increase rapidly in size and are at

[1] *Zeit. f. Pflanzenkr.*, Bd. vii, p. 65.

first surrounded by very numerous radiating filaments of kinoplasm. The division of the generative cell results in the formation of two antherozoid cells, one blepharoplast being contained in each. During this division the blepharoplasts, which have previously lost their radiating filaments of kinoplasm, burst, and the outer membrane of each becomes gradually extended into a narrow helicoid spiral band, from which the motile cilia of the antherozoids are developed. In fecundation this ciliiferous band, formed from the blepharoplast, is left intact at the apex of the archegonium, the nucleus alone taking part. No bodies resembling centrosomes have yet been found in the divisions resulting in the formation of the pollen grain or in the divisions of the egg nucleus after fecundation.

In conclusion it was stated that the blepharoplasts resemble centrosomes: (1) in position, being located on opposite sides of the nucleus near the poles of the future spindle; (2) in having the kinoplasmic filaments focused upon them during the prophases of the division of the generative cell. They differ from typical centrosomes, however: (1) in arising *de novo* in the cytoplasm; (2) in growing to comparatively enormous size; (3) in not forming the center of an aster at the poles of the spindle during karyokinesis; (4) in having a differentiated external membrane and contents; (5) in bursting and growing into a greatly extended cilia-bearing band, the formation of which is evidently their primary function; (6) in their non-continuity from cell to cell. The conclusion reached by the speaker was that in our present understanding of centrosomes the blepharoplasts must be considered as distinct organs.

DR. ROBERT A. HARPER: *Spore Formation in Some Sporangia.* Protoplasmic cleavage and spore formation in types from the genera Synchitrium, Pilobolus, and Sporodinia were described. The division of the multinucleated sporeplasm is neither simultaneous nor by repeated bipartitions, but is accomplished by the progressive growth of narrow cleavage furrows from the surface inwards. In *Synchitrium decipiens* this results in the formation of uninucleated spores, which, by subsequent division of their nuclei, become the resting zoösporangia of this species. In *Pilobolus crystallinus* a similar progressive cleavage produces oval or sausage-shaped masses, which have one or several nuclei. These nuclei now divide, and the plasma masses in which they are also divide by constriction, thus forming ultimately the definitive binucleated spores. In Sporodinia the process is much abbreviated, the primary cleavage furrows simply dividing the protoplasm into relatively few and very unequal multinucleated masses,

which round themselves up and are set free at once as spores. In Pilobolus the so-called collar is composed of a slime which is readily distinguished from protoplasm, both by its structure and staining reactions. Cleavage consists in the ingrowth of the plasma membrane. The whole process of spore formation in these sporanges is fundamentally different from that in the ascus, and is strong evidence that ascus and sporangium are not homologous structures.

WALTER T. SWINGLE: *Two New Organs of the Plant Cell.* The author announced the finding of two new organs or organoids; the one, vibrioid, being abundant in the superficial layer of the cytoplasm of some Saprolegniaceæ and some Florideæ, the other being a central body in the developing egg of *Albugo candidus.* The vibrioids are slender, cylindric, sharply delimited bodies about the size of many common bacilli, but exhibiting rather slow bending or undulatory proper motions in addition to transitory movements, which are probably passive and due to the streaming of the cytoplasm in which they are imbedded. They are fixed well by ordinary killing agents, and when stained are very sharply differentiated from the surrounding cytoplasm. They can also be seen in the living cell. Their appearance suggests that they may be minute entoparasites, but their constant occurrence in plants in all stages of development and from widely separated localities militates against this view. Their function is unknown.

The other new organoid is a nearly spherical body, located at one end of the egg nucleus of *Albugo candidus.* It is often a little flattened on the side adjoining the nucleus, is not very sharply delimited from the cytoplasm, but stains differentially. It seems to be more or less granular in structure; it appears just before delimitation of the egg within the oögonium, and disappears after fusion of the male and female nuclei; it probably plays some part in these two phenomena.

Both of the organoids have been observed before, but were not correctly described by previous writers.

B. M. DUGGAR: *Notes upon the Archesporium and Nucleus of Bignonia.* In the microsporangium the archesporium occupies a single boat-shaped layer. The primitive archesporium is differentiated by periclinal division in certain regions of the hypodermal layer, the next divisions in the latter giving rise to the tapetum on the outer side, and the final division of the succeeding hypodermal layer developing that layer often becoming the fibrillar endothecium of authors. In Bignonia there is no fibrillar structure, and, in general, no further

periclinal divisions in the regions mentioned. The definitive archesporium is formed by not more than a single anticlinal division of the primitive archesporial cells.

The macrosporic archesporium apparently develops no primary tapetum, divides simultaneously from the two-celled stage, and the third or fourth cell becomes the definitive embryo sac mother cell.

The archesporial nucleus, especially, is peculiar in the large nucleolar-like structure, which is evidently not homogeneous in structure, a portion of it taking the gentian in the Flemming combination.

WALTER T. SWINGLE: *Some Theories of Heredity and of the Origin of Species Considered in Relation to the Phenomena of Hybridization.* Owing to limited time, the speaker treated only the first portion of his theme, *viz.*, the bearing of the facts of hybridization on some theories of heredity. It was pointed out that Weismann's theory of reduction of chromosomes, though giving a plausible explanation of the differences observed between the first (uniform) and second (polymorphic) generations of most hybrids, is not in accord with the observed phenomena of spore and pollen formation in higher plants, and, moreover, fails to account for the extreme polymorphism often observed in the first generation of hybrids of races of cultivated plants or closely related species, as, for example, some racial hybrids of maize and some specific hybrids of Lychnis and Digitalis. Mr. Swingle considered it necessary to assume in some such cases, at least, a predetermination of the characters of the hybrid at the time of fusion of the male and female nuclei.

Since the male and female chromosomes probably persist side by side unchanged in number, and possibly unchanged in quality during the whole of the ontogeny of the hybrid (reduction not occurring until the close of the first generation), it is therefore necessary to assume, in order to explain the observed fact of divergence of character in the first generation of some hybrids, that the influence exerted during ontogeny of the hybrid by the material bearers of heredity is, at least in some cases, a function of their relative positions, and, further, that in most cases the relative positions of these bearers of heredity, as determined at the moment of fusion of the male and female nuclei, would persist unchanged throughout ontogeny of the offspring. Some exceptional cases, such as reversions to the one or the other parent form of a larger or smaller part of the hybrid, would be explained by assuming some change in the disposition of the units of hereditary substance, whereby they assumed a new posi-

tion of partial or complete stability. It was suggested that possibly the difference between uniform and polymorphic hybrids of the first generation is due to a more complete intermingling of the hereditary particles in case of polymorphic hybrids (offspring of closely related organisms), whereby many differing combinations would be possible, and, in case of uniform hybrids (mostly offspring of distinct species or very different races of the same species), to greater or less aversion to commingling between the two more diverse sorts of particles, whereby but one uniform and stable configuration would result, allowing both sorts of hereditary substance to act equally.

Xenia, or the communication of the paternal characters to parts of the mother plant in the immediate neighborhood of the developing embryo, was held to be well established in case of some races of maize by the work of Dudley, Savi, de Vilmorin, Hildebrand, Körnicke, Sturtevant, Burrill, Kellerman and Swingle, McCluer, Tracy, Hays, and others, and in case of some races of peas by the work of Wiegmann, Gärtner, Berkeley, Laxton, and Darwin. The converse phenomena of the mother plant influencing the characters of the developing embryo is occasionally reported; for instance, in hybrids of Digitalis, by Gärtner, and in hybrids of Nymphæa, by Caspary.

These phenomena are inexplicable by the current theories of heredity, and perhaps in consequence have been neglected. They necessitate the assumption that hereditary influences can be transported from cell to cell for some distance. It was suggested that this transport may occur either along the intercellular filaments which pass through the walls, or by means of diffusible substances capable of acting on the hereditary particles of distant cells. Townsend's proof of the conduction of the stimulus which results in wall formation over long, slender threads of protoplasm in plasmolyzed cells may be considered as hinting the possibility of the former explanation, while Beijerinck's claim that the developing larvæ of some gall insects secrete substances which diffuse into and control the ontogeny of neighboring meristematic or partially developed tissue cells of the host plant foreshadows the latter hypothesis.

DR. G. E. STONE: *Influence of Electricity on Plants.* Read by title.

ALBERT F. WOODS: *Variable Reaction of Plants and Animals to Hydrocyanic Acid.* Experiments cover a period of three years. The plants and animals were exposed in air-tight chambers of known cubic

contents for a given period to a definite amount of gas obtained from a solution of 98% (*i.e.*, c. p.) potassic cyanide in 50% sulphuric acid, KCN + H_2SO_4 + aq. Plants of the Coleus group which we have tried will stand in all stages of growth the gas produced from $\frac{15}{100}$ of a gram of 98% cyanide of potassium per each cubic foot of space for 25 minutes. A longer exposure, even for so short a time as 5 or 10 minutes, results in more or less injury, and exposure to the gas from $\frac{20}{100}$ gram per cubic foot for 25 minutes also results in injury. In the latter case, if the time is cut down to 10 minutes the plants may stand the increased dose without injury. The ratio between the doses and the time is not constant. The plants can endure strong doses for a very short time much better than they can a weak dose for a long time. Under conditions where the stomata of the plant are closed, it can resist the gas for a much longer period than it can where they are open. The temperature of the chamber also has an important effect. If it is high, it increases the diffusibility of the gas and decreases the time which the plant can be exposed without injury. If the temperature is low, the time may be lengthened.

Ferns, *e.g.*, Davallias and Adiantums, are able to withstand a slightly longer treatment than Coleus. Even the very youngest developing fronds are not injured at the upper limit of the treatment which would injure the young leaves of Coleus. There are a large number of plants of different families which seem to be able to endure exposure, as indicated for Coleus and Adiantum, without injury. Tomatoes, on the contrary, are very sensitive. All the young growth is killed by an exposure of 15 minutes to the gas from $\frac{15}{100}$ of a gram of 98% KCN per cubic foot of space. In fact, it is hardly possible to give these plants any dose so small that it will not injure some of the young growth. The young growth of roses is also remarkably sensitive, it being almost impossible to treat them without injury. Different varieties of roses, however, seem to differ in this respect. The older leaves of tomatoes and roses are much less susceptible. A curious effect of the poison was noted on tobacco, on *Lilium candidum*, and on tomatoes, where the dose was not great enough to kill the plants, but simply to injure them slightly; all the affected cells lost their chlorophyll, and, although they continued to divide and grow, they were colorless, producing yellowish white blotches in the leaves, especially along the veins. In case of woody stems the cells immediately under the cambium, *viz.*, the youngest wood cells, were most sensitive. In many cases these were killed, much as if by frost, but the stems continued their growth.

Variations of a similar nature were noted also in insects, and some of these are well known to entomologists who use cyanide bottles. Spiders and all of that group seem to be particularly resistant to the poison. The mites are the most resistant organisms thus far studied, but even among species of aphides some are much more sensitive than others. The red mite (*Tetranychus telarius*) is very resistant. In cases where complete paralysis is produced and there are no signs of life for several hours mites frequently recover. Some of the higher animals also behave in the same way.

GILBERT H. HICKS: *Effect of Light on the Germination of Seeds.* Read by title.

A. J. PIETERS: *Effect of Alternating Dryness and Moisture on the Germination of Some Seeds.* The species experimented with were *Chenopodium album*, *Daucus carota*, *Anthemis cotula*, *Arctium lappa*, *Cichorium intybus*, *Dianthus armeria*, *Echium vulgare*, *Datura tatula*, *Malva rotundifolia*, and *Verbascum blattaria*. Two pots were devoted to each species. After the seeds were sown the pots were under uniform and like conditions, the soil being kept continuously moist. After a long period, during which germination had practically ceased, the soil in one of the two pots was allowed to become thoroughly dry, and remained so for two weeks. It was then moistened regularly, whereupon many seeds germinated. This was true of all the species mentioned. Two examples are selected at random from the list. *Daucus carota:* During the first 39 days pot *A* germinated 14%, and pot *B* 15%. No further germinations for 98 days. *A* was then kept dry for 14 days; *B* moist as usual. Germination began in *A* 2 days after watering, and in 4 days *A* germinated 15%, while in the previous 18 days *B* had germinated 0. Both pots were subsequently left dry from August 7 to September 8, and then moistened. Germination in both pots began September 11, and in 17 days *A* germinated 9%; *B*, 30%. *Dianthus armeria:* In first 111 days *A* germinated 32%; *B*, 42%. *A* was then dried 14 days, while *B* was continued moist. Beginning July 27, *A* was moistened regularly. On July 30, germination began in *A*, and in 10 days *A* germinated 52%. During the previous 24 days *B* germinated 0. Both pots were dry from August 7 to September 8, then both were regularly moistened. Germination began September 13. In 15 days *A* germinated 2%, and *B* 40%. Equally striking results were obtained with other species. In many cases germination began in the dried-out pots within 48 hours, and in some cases within 24 hours after the watering. A few other

species which had shown no germinations in the moist soil were not affected by this treatment. These experiments will be repeated and extended before final publication.

PROF. GEO. F. ATKINSON: *Experiments on the Morphology of Arisæma triphyllum.* Female, male, and neuter plants, the history of which was known by growing them in pots for one season, were potted, some in rich soil and others in poor soil, the object being to change them from male to female, etc., by varying amounts of nutriment. Male plants in rich soil were in one year changed to female, and large neuter plants in rich soil were changed to female.

In a second series, large two-leaved female plants with large corms were selected at the time the rudiment of the flowers was formed. The corms were cut so as to remove all but a small portion in connection with the bud and then set out. By removal in this manner of the larger part of the stored food, the plants were changed to male. A collection of these plants was exhibited.

DR. W. F. GANONG: *Upon Polyembryony and its Morphology in Opuntia vulgaris Mill.* The author has found this species markedly polyembryonic, the polyembryony having a double morphological basis. One set of embryos comes from a mass of tissue which appears to develop from the fertilized egg cell, and others spring from the wall of the embryo sac and seem to arise from endosperm cells. If this be true, it is a mode of origin hitherto unknown. The literature of the subject was summarized, and some remarks given upon the significance of polyembryony. Many species of cactus were worked over (eighty or ninety), and no other cases observed.

DR. W. F. GANONG: *Contributions to the Morphology and Biology of the Cactaceæ. Part II, The Comparative Morphology of the Embryos and Seedlings.* The paper is a continuation of the author's earlier studies upon this family. It describes and figures germinated embryos of most of the genera and the more important species, discusses the germination and growth of the embryos, their form, size, and color factors, and the features they show of importance for the determination of the phylogeny of the genera, the development of the seedlings, and the unfolding of the peculiar morphological features of the adult plants. Contrary to Pfeifer, the morphology of the group is of systematic importance. A tree of descent was exhibited. Anhalonium and some other genera were shown to belong with genera from which they have heretofore been widely separated. Many interesting drawings were exhibited.

DR. W. W. ROWLEE: *The Morphological Significance of the Lodicules of Grasses.* This study was based on an examination of bamboo flowers, in which genus three to six lodicules are present. In floral structures the bamboos are believed to represent the primitive type of grass flower. Evidence obtained from an examination of numerous sections of the bamboo flower indicate that the lodicules must be regarded as the remnants of a perianth. The three lodicules in Arundinaria alternate on the axis with the stamens, and may, therefore, be considered the inner whorl, or petals. The stamens are directly opposite the midribs of the carpels, and indicate that the inner whorl of stamens, present in some bamboos, is suppressed in Arundinaria. Hackel, as is well known, interpreted the lodicules as distichous bracts. The paper was illustrated by lantern slides.

DR. LUCY L. W. WILSON: *Observations on the American Squawroot (Conopholis Americana Wallr.).* An exhaustive study of the vegetative and reproductive parts has been made, but an account of the former only was read. The invariable host plant is the oak. The extreme degradation of the parasite and the intimate relation between it and the oak roots caused the author to compare it with members of the Balanophoreæ and Rafflesiaceæ, rather than with parasitic members of the Scrophulariaceæ. The seedling parasite seemed early to attack young oak roots, and steadily grew for ten to twelve years until a huge mass six inches across might be formed. This mass was characterized chiefly by the abundance of sclerenchyma patches developed by the oak host through the irritant action of the invading parasite. The presence of stomata on the stem and their absence on the scale leaves was pointed out, while the double circle of bundles traversing the flowering stem is peculiar in that the xylem of one of these sets of bundles faces the xylem in the other.

DR. JOHN W. HARSHBERGER: *Water Storage and Conduction in Senecio præcox DC. from Mexico.* *Senecio præcox* (Cav.) DC. is a plant with a succulent, woody, cylindrical stem growing on lava beds in the valley of Mexico. It has clustered leaves at the top of the stem and stores up water in disk-like plates of pith. During the dry season the plant develops its corymb of composite flowers, and in doing so uses the water stored up in the pith. The loss of this water is prevented during the dry season by the fall of the leaves and by a protective cork and balsam, the latter secreted in the exocortex and endocortex. The leaves show no xerophytic structure. The water stored in the turgid disks of pith is gradually conducted by the woody

cells and tracheids to the growing point. That the water in the pith is a reserve supply is shown by examination of a piece of stem, which was still alive and sending out small green leaves and short shoots, although it had been cut and in a dry place for over sixteen months. In this stem the turgid disks of pith were contracted into parchment-like membranes or partitions. Conduction of water in the stem was accomplished without the assistance of root pressure and without the aid, to any appreciable extent, of the transpiration from the extremely small leafy crown.

K. M. WIEGAND: *Notes on the Embryology of Potamogeton. Potamogeton pauciflorus* was studied with regard to the origin and development of the embryo sac, fertilization, and the development of the embryo. The embryo sac was found to arise in the normal manner for monocotyledons, *viz.*, from the subepidermal cell after the cutting off of a tapetal cell. The egg apparatus and antipodals were, however, somewhat abnormal. Although the normal number of cells in each was present, they were formed irregularly. The polar nucleus and first and second synergides seem to have been cut off successively from the mother nucleus of the egg. The synergides disappear almost immediately. A similar irregularity was found in the antipodals; but the most interesting feature, perhaps, was the fact that the definitive nucleus cuts off a very large basal nucleus, as in Sagittaria, before endosperm formation proceeds in the upper portion of the sac.

DR. ADELINE SCHIVELY: *Recent Experiments and Observations on Fruit Production in Amphicarpæa monoica.* Her published observations show that minute aerial cleistogamous flowers when buried produce one-seeded "nuts" with soft fruit and seed coats, instead of the typical two to three-seeded pods with indurated walls.

She now shows that when purple flowers are buried, in the bud state, while still attached to the plant, or at any period up to the time of fertilization, perfect underground "nuts" mature instead of three to four-seeded pods. Various conclusions were drawn as to the powerful action of environmental agents in determining the size, shape, and consistence of the seed, the induration of its coats, and the number of seeds that might be produced.

DR. MARTHA BUNTING: *On the Formation of Cork Tissue in the Roots of the Rosaceæ.* Starting with observations on *Geum urbanum* and *Geum rivale* made by Professor Macfarlane in 1890, where intercellular spaces were shown to exist between the cork cells, she

proved this condition to be typical for all herbaceous and shrubby species examined, but to be absent in roots of arborescent species. She described the alternation of a flattened, usually pigmented, layer of cells with one to three layers of rounded cells in each annual ring, the flattened layer being the last produced each season. Protoplasm, nuclei, and starch grains exist in cork zones four to five rings removed outside the phellogen.

Miss Caroline Thompson: *The Structure and Development of Internal Phloem in Gelsemium sempervirens Ait.* The phloem originates as four longitudinal tracts in the primary meristem and steadily increases, until by the eighth or tenth year it has entirely pressed together and destroyed the pith. During the first year nourishment of the pith ceases, owing to the differentiation of two layers of cells, which were referred to as the "phloem sheath."

A remarkable distribution of the internal phloem was shown to exist in the petiole, at the base of which a bicollateral bundle arrangement exists, but this quickly changes to the ordinary collateral relation by the passage of the upper (internal) phloem through the xylem of the petiole. Each bundle in passing out into the petiole subdivides into three parts, two of which remain in the stem and soon reunite, while the third passes out and behaves as above described.

From the second year onward, the internal phloem patches of the stem show areas of crushed and obliterated tissue where the previously formed phloem has been pushed inwards by the younger elements. In older stems eight large phloem patches, formed by division of the original four, entirely fill up the pith area.

SOME CHARACTERISTICS OF THE FOOTHILL VEGETATION OF WESTERN NEBRASKA.[1]

CHARLES E. BESSEY.

In another paper read before this section[2] I have spoken of the general features of the foothill portions of Nebraska, and I need do no more here than to say that the foothill region includes a belt from 100 to 200 kilometers in width, covering the extreme western counties and lying for the most part west of the 102d meridian. It is characterized physically by two long ridges which extend out from the Wyoming Mountains to the eastward. The northern one is Pine Ridge, with an elevation of about 1500 meters, and the southern one Cheyenne Ridge, with an elevation of 1700 meters. Each slopes gradually to lower levels, and, after 200 or 300 kilometers, they are raised but little above the surrounding country. It must be borne in mind that the whole of the western portion of the state is greatly uplifted, the general level for the last one-fourth of the surface being fully 1200 meters above the sea.

A recent botanical journey of about 175 kilometers in this region enables me to present at this time a few features of the vegetation which have not hitherto been particularly noticed.

At Alliance in Box Butte County, the point of beginning, the surface is a gently undulating plain, with an elevation of 1200 meters above sea level. Here, as far as the eye can reach, there are no native trees whatever and scarcely any shrubs. The plants which dominate everywhere are *Agropyron pseudo-repens*, *Stipa comata*, *Bouteloua oligostachya*, and *Bulbilis dactyloides*, with *Opuntia mesacantha* and *Cactus viviparus* abundantly scattered among the grasses. *Lepidium intermedium* entered into these grass formations quite constantly, and in some places constituted nearly, if not quite, one-half of the vegetation.

[1] Read before section G of the American Association for the Advancement of Science, Aug. 11, 1897.

[2] "Are the Trees Receding from the Nebraska Plains?" since published in *Garden and Forest*, Nov. 17, 1897.

For fifty kilometers the vegetation is of this monotonous character, the monotony intensified by the straw color now assumed by the dry vegetation. Only when we cross the broad valley of Bluewater Creek do we find a marked departure from the Agropyron-Stipa-Bouteloua-Lepidium formation. The increased moisture has enabled other grasses to push their way in, especially *Sporobolus aroides*, and this with Agropyron, which here is taller and quite green, give a refreshing color to the stretch of level land on each side of the creek. We cross a stretch of rounded sand hills over which the vegetation is still more sparse, but yet it is only a modified form of the Agropyron-Stipa-Bouteloua-Lepidium formation. As we enter and as we pass out of these dry hills, we cross a belt, or zone, of *Artemisia filifolia*, which begins and ends with marked abruptness.

The valley of the North Platte, thirty kilometers from the western boundary of the state, is from six to sixteen kilometers in breadth, and here, on account of the general introduction of cultivated plants under irrigation, the botanist finds little of the original vegetation. The river banks and the sandy islands scattered here and there in the rapid current are fringed with young willows (probably *Salix nigra*) and buffalo berry, but there is no heavy body of woodland, as we should find under similar conditions in the eastern part of the state. Doubtless the greater elevation (1100 meters) above sea level has much to do with this absence of trees along the banks of the great river, which is fully a kilometer in breadth.

Upon crossing the river we soon begin the ascent of Cheyenne Ridge. In its narrow cañons, which open to the north, we find cottonwood (*Populus deltoides*), Rydberg's cottonwood (*Populus acuminata*), almond willow (*Salix amygdaloides*), boxelder (*Acer negundo*), plum (*Prunus americana*), hackberry (*Celtis occidentalis*), and red cedar (*Juniperus virginiana*), while on the sides of the bluffs were scattered specimens of pine (*Pinus ponderosa scopulorum*). Here grow side by side the western shrubs, *Rhus trilobata*, *Prunus demissa*, *Rosa fendleri*, *Ribes aureum*, *Lepargyræa argentea*, and the eastern *Symphoricarpos occidentalis*, *Parthenocissus quinquefolia*, and *Vitis vulpina*. Passing still further up the side of the ridge, we find the smaller moun-

tain mahogany (*Cercocarpus parvifolius*) in great abundance on the steep slopes. Here the pine is the principal tree, growing abundantly in the deep cañons and upon the exposed mesa-like summits of the rocky spurs.

After we reach the top of Cheyenne Ridge, we find broad stretches of grassy meadow land which are comparable to the mountain meadows of the great range to the westward; and yet here the summits, which here and there rise 100 meters or more above the general elevation, are capped and fringed with pines. The Wildcat Mountains constitute one of these series of higher summits, attaining an altitude of fully 1700 meters, and their summits and slopes, as well as tortuous cañons, bear pine trees here massed and there widely scattered. From the highest point of Cheyenne Ridge, as we pass southward, there is a gradual return to the type of Agropyron-Stipa-Bouteloua-Lepidium which we found on the high plains north of the North Platte River. As we pass ridge after ridge, each a little lower than the preceding, we gradually lower our elevation until we run down into the valley of the Lodge Pole River, 1450 meters above the sea. The last ten kilometers have nearly duplicated the floral covering of the Box Butte Plains, with somewhat less of the effects of aridity in its general aspect, and with here and there a cottonwood, box-elder, or willow tree along the river to relieve the monotony of the landscape.

BRIEFER ARTICLES.

ADVENTITIOUS BUDS ON LEAVES OF DROSERA ROTUNDIFOLIA.

A. J. GROUT.

WHEN collecting plants of *Drosera rotundifolia* for class use, I found several leaves bearing numerous (from two to ten) young plants on their upper surfaces (Fig. 1). This fact was first noted about Sept. 15, 1897.

So far as I can learn, this peculiarity of the sun dew has escaped observation until the present year. At the time I made the discovery I knew of no other similar observations, but have since learned that Mr. James A. Graves,[1] of Susquehanna, Pa., has noted the same thing this fall. That these facts have never before been noticed seems all the more remarkable since *Drosera rotundifolia* has been made the object of such careful scrutiny by Darwin and others because of its carnivorous habits.

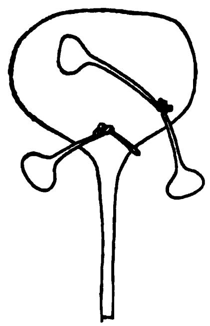

FIG. 1. — Leaf of *Drosera rotundifolia* with two young plants.

The most favorable spots for this peculiar development seemed to be among dense masses of Sphagnum, and the leaves producing the adventitious buds lay directly upon the wet moss. A few of the leaves had entirely severed their connection with the old plant, but no roots had developed in the young plants at the stage represented in the figure. Mr. Graves's Drosera developed the adventitious buds in a moist chamber.

The occurrence of the adventitious buds in such wet places suggests that the past extremely wet season may explain their discovery at this particular time; that is, the unusual amount of moisture has caused the formation of an unusual number of buds.

Another interesting fact observed was the occurrence of the peculiar glandular hairs of the leaves a short distance up on the stems of the young plants, as if the tissues of the stem still retained some of the peculiarities of leaf tissues.

[1] *The Plant World*, vol. i, no. 2.

Sections through the leaf and base of young stems have been made, but the apparatus at hand does not permit of a section thin enough to give structural details. The organic connection between the leaf and the base of the young stem is clearly shown, and the young plant evidently starts in connection with the fibro-vascular bundles of the leaf, but my sections do not clearly show the nature of the connection.

The cells of the very base of the young stem and the adjoining leaf cells were crowded with chlorophyll grains, while there were very few in the other leaf cells, showing clearly the much greater constructive activity (anabolism) of these tissues.

PLYMOUTH, N. H.

NOTES ON THE FOSSIL MAMMALIA OF EUROPE.

CHARLES EARLE.

VI.

Remarks on the Fossil Tapiroids of France.

As far as our paleontological knowledge stands in regard to the evolution of the modern tapirs, this phylum arose in Europe and America at about the same time. In America we find in the Bridger the genus Isectolophus, which is considered to represent one of the stages leading to Tapirus.

Prof. Albert Gaudry has lately published an important paper[1] on the evolution of the teeth of fossil Tapiroids and refers remains found in the Middle Eocene of Argenton, France, to the American genus Colodon, which he includes in the tapir phylum. Now, in the first place, Colodon comes from the Oligocene, or White River Beds, whereas the beds at Argenton are equal to the Middle Eocene, or Bridger. The teeth which Professor Gaudry has referred to *Colodon minimus*, in my opinion, should be identified as those of the American genus Isectolophus, or a very closely related genus. This is more in harmony with the origin of the tapir's tooth, as in Colodon the metacone is concave, whereas in Isectolophus this cusp is convex, like that of the recent tapir.

[1] La dentition des Ancêstres des Tapirs, *Bull. Soc. Geog. de France*, p. 315. 1897.

In fact, I am not at all certain that Colodon is found in Europe, even in beds above the Eocene. The *Protapirus douvillei*, which has been referred by some American paleontologists to Colodon, is, as I have shown,[1] really a true tapir and belongs in the genus Protapirus, which is one of the generic links leading to Tapirus.

Again, *Hyrachyus intermedius* of Filhol has been placed by M. Gaudry as a synonym of *Colodon minimus*. I can hardly agree with my learned friend of the Jardin des Plantes in this identification, and I think the jaw and teeth referred by Filhol to the genus Hyrachyus were correctly identified.

In the jaw of the French species of Hyrachyus, described by M. Filhol, the number and structure of the teeth are the same as in the typical American species of this genus, and there is no third lobe on the last lower molar. The measurements of the jaw and teeth of *H. intermedius* correspond nearly exactly with those of *Hyrachyus agrarius* of the Bridger.

The presence of such typical American Middle Eocene genera as Hyrachyus and Isectolophus in the Eocene of Argenton, France, demonstrates how closely this fauna is related to that of the Bridger.

So far as I am aware, the larger species of Lophiodon are not found at Argenton, *L. isselensis* coming from Issel. We might conclude from this that the Argenton beds are really earlier than those of Issel, and this would harmonize better with our ideas of the dental morphology of the tapirs, as it is more probable that the types with a convex metacone, Isectolophus, gave origin to both tapirs and lophiodonts than that the latter were ancestral to the tapirs. The typical forms of Lophiodon, as *L. isselensis*, probably led to no permanent results in regard to evolving higher genera.

In conclusion, the evidence is now pretty conclusive that Hyrachyus is found at Argenton, and a decided advance has been made by Professor Gaudry in the removal of one of the small species of Lophiodon from that genus, but whether the view is correct that it is a species of Isectolophus remains to be seen. The third species of Lophiodon which was referred by Cuvier to this genus is now placed by Professor Gaudry in Propalæotherium. The mist has now considerably cleared away in regard to What is Lophiodon? In France, at least, all of the small species have been accounted for and referred probably to their proper genera.

[1] *Science*, Dec. 25, 1896.

VII.

Note on the Structure of the Skull in Dichodon.

The genus Dichodon has been recorded from the Eocene of Hordwell, England, at Egerkingen by Rütimeyer, and also is found in the Siderolithic du Mauremont. While at Paris in 1895, I had the opportunity of examining part of a skull from the Phosphorites, labeled *Dacrytherium cayluxi.* I at once noticed the modernization of this skull and the characters of the teeth, and immediately referred it to that little-known genus Dichodon of Owen. This genus has not, I believe, been recorded before from the Phosphorites of France.

In Dichodon the fourth upper premolar is completely molariform; it resembles Agriochoerus in this respect somewhat, but in the latter this tooth has not developed the postero-internal cusp. Dichodon stands unique among Artiodactyles in the complex structure of the last premolar.

The facial part of the skull in Dichodon is high and strongly compressed. The anterior narial openings are not as terminal in position as in the Anoplotheroids, with a corresponding reduction in the nasal bones, obliquity and enlargement of the nares. As compared with Dacrytherium, there is no preorbital fossa, and the facial part of the skull in Dichodon is much more modernized than in the former genus.

In comparison with modern selenodont Artiodactyla, the anterior portion of the skull in Dichodon closely resembles that of the Tylopoda and departs widely from the primitive type found in the Anoplotheres.

With the exception of the closed dental series in Dichodon, this genus has apparently little near relationship to the Anoplotheres, but is a much higher type and more nearly related to the true Selenodonts.

New Rochelle, N. Y.,
January 24, 1898.

EDITORIALS.

A New Biological Journal. — We have the pleasure of recording the advent of another excellent periodical from France devoted to biology. *L'Intérmediaire des Biologistes, organe international de Zoologie, Botanique, Physiologie, et Psychologie*, the first number of which appeared November 5, is edited by Prof. Alfred Binet, with the assistance of Dr. Victor Henri and an editorial committee of thirty-four, including Profs. J. M. Baldwin and C. S. Minot from America. The journal, which is to appear semi-monthly, cherishes the high ideal of becoming the medium of communication between the members of the great family of biologists scattered in all countries. The immediate practical aim is that of furnishing to biologists information of interest to them as investigators. This information will be afforded, first, by a department of "Questions and Answers," and, secondly, by summaries of the biological periodicals. In addition, a brief space may be devoted to original articles and preliminaries. The number now before us contains "An Appeal to Physiologists," by E. J. Marey, for the establishment of a commission to make the types of instruments used in physiological work uniform; forty-six queries, largely in psychology, nearly all instructive by their suggestiveness; bibliographic lists of contents of periodicals, eight pages; three new pieces of physiological apparatus, with illustrations. Of the importance of such a journal as this we have no doubt. In how far it will serve the working naturalist who wants certain information is yet to appear. Generally he wants it quickly; but not infrequently the queries will relate to a life work, when he can afford to wait, as Darwin did, months and even years for the answers to his questionings. But whatever this journal does towards uniting biologists, towards establishing a habit of mutual dependence and aid, will not fail to advance the science.

Scientific Names. —There has recently come into our hands a small paper of no little value to systematic naturalists. We refer to Professor Walter Miller's "Scientific Names of Latin and Greek Derivation," published in the *Proceedings of the California Academy of Science* and reprinted by the Stanford University. The paper should be a *vade mecum*, studied and restudied by every person who is in danger of describing new genera and new species. Were its

teachings followed we should not have our tastes shocked by such hybrid names as Gillichthys; we should no longer have to see feminine adjectives coupled with masculine nouns; we should no longer be in doubt as to whether Alcyonaria or Halcyonaria, Aplodinotus or Haplodinotus was the preferable form.

We wish, however, to make use of the paper as a text, rather than for a regular review. From one standpoint the appearance of this paper is to be regretted. There is danger of its falling into the hands of those who will feel it their duty to reform nomenclature in accordance with the rules there laid down and thus inflict upon a suffering world a new series of useless terms. There are people who cannot realize that our system of systematic nomenclature is not an end but a means. It is really the foundation of our book-keeping, and to change this book-keeping from day to day is far from facilitating actual work. We are told that the whole endeavor of the systematic purists is to result in permanence, but we have been waiting for this permanence now these many years, and, so far as we can see, it is as far off as ever.

We have no fault to find with the law of priority, no fault with the rule that names shall be formed in consonance with the laws of philology. What we do find fault with is the feeling that these man-made laws are inviolable and the evident disinclination to use that best of gifts, common sense, in their application. All the world knows what Amphioxus is. The name is used in every paper dealing with its structure, but the law of priority demands that Branchiostoma be substituted for it. Were it possible to make the substitution, would there be any more permanence than if the better-known name be left alone? Lepidosteus is in almost world-wide use. Is permanence effected by resurrecting the fact that, in defiance of the laws of euphony and philology, its original form was written Lepisosteus?

But these are not the worst cases to bother us. The most absurd are those changes which are based upon the law that names of similar origin but of different form are in conflict, and that the later one must stand aside on the ground of possible misunderstanding. Ellobius must go because Ellobium was described first; Gymnura must be renamed because of possible confusion with the earlier Gymnurus. These are little better than those cases of changes proposed because of alleged inappropriateness or inaccuracy of name.

We who are not engaged solely in systematic work are beginning to get weary with this continual shuffling and changing of names. We do not find that fixity which we had been led to expect. Names

are less certain in their meaning than they were twenty or thirty years ago. Who can tell to-day what a writer means if he mentions some fact about *Acer saccharinum?* One must first be acquainted with the mental composition of the author; is he radical or is he conservative in his make-up?

We can suggest no better business for the American Association for the Advancement of Science than the appointment of a committee to take the initiative in reopening this whole question of laws of nomenclature, and in the appointment of such a committee care should be taken that morphologists and physiologists as well as systematists should be recognized in its make-up. It would be desirable to see if it be not practicable to institute some law of limitation to the priority rule, or there will always be those who will write Astacus when they refer to the lobster. Such a committee could coöperate with other similar bodies appointed by other scientific organizations elsewhere, and thus make some laws of universal application.

Marvelous Technique. — At various times during the past year the daily papers have contained accounts of a wonderful discovery on the part of an alleged American professor to the effect that he had been able to increase the magnifying power of the microscope to an extent hardly dreamed of by other workers. So long as these accounts were confined to the daily press we took no notice of them, but now that they have obtained entrance into such a worthy journal as the *New York Medical Times* we think it time to lodge a protest. The "discovery" is in effect the insertion of a second microscope in the place of the ocular of the first. It is true that this will result in an amplification of the image, but every tyro knows that this process is an old one, and that, while an enlargement results, there is no gain in definition; it is merely a magnification of the imperfections of the first objective. Still greater amplification than any this so-called professor claims can be obtained by the simple projection microscope, but no one who has seen a nucleus thus "thrown up" until the image has a diameter of six or eight feet will claim that the process discloses features before invisible.

The same brilliant discoverer announces also a still more brilliant discovery in technique by which he has been able to obtain sections "of about one one-hundredth the thickness of the finest slice ever hitherto obtained." For refinement of technique his procedure "beats the Dutch." "I cemented upon a glass slide a single layer of cells, and then placed upon this slide another slide whose surface had been freshly covered with cement and allowed them to remain in

contact until the upper and lower surfaces of the cells had become cemented to the glass slides. Then I introduced between the two glass plates a very thin blade of copper (!), the edge of which had been sharpened to the very finest cutting surface possible. . . . This blade is introduced between the two plates and pushed along between them so as to separate them, and on its way it slices the cells in the middle. One of these plates is then cemented to another glass plate with the cut surfaces of the cells against the other glass plate and the slicing operation repeated," *ad infinitum*.

The same article proceeds next to the superlative. No longer will Spencer's well-known characterization of life be quoted. Our brilliant professor has solved the problem. "I am satisfied," says he, "that life is mind — that all vital phenomena are mental. A cell can feel stimuli and can *adapt acts* to *ends* (*sic*). Now, only mind can do this; only animate bodies have minds, and mind alone it is which constitutes their life." There follows much more of the same sort, but we have no room for further quotations. Some years ago the *American Naturalist* (vol. xxi, p. 549) advertised for an author for a much needed "Unnatural History," stating the qualifications necessary in the person who should undertake the work. The author is now found, and if the present flow of lucubrations be continued, the volume missing from all libraries will soon be an accomplished fact.

The Society for Plant Morphology and Physiology. — In the formation of the Society for Plant Morphology and Physiology an important step has been taken for the advancement of botany in America. We have no intention of assuming the functions of a scientific newspaper, but the first annual meeting of this society is an event of such significance that we are very glad to publish the report of its proceedings, which is presented on another page. At this meeting the workers on the morphological and physiological sides of botany have come together for the first time as a distinct body, and one is able to obtain for the first time a comprehensive view of what is being done in this country along these lines of investigation. There was, naturally, considerable variation in the quality of the papers presented, but one cannot fail to be impressed with the variety and amount of work which they represent and their generally excellent character. Certainly the society is to be congratulated upon the success of its first meeting, and no doubt its meetings in the future will be of even greater interest, and will exert a profound and broadening influence not alone upon the botany in this country but upon the biology in general.

REVIEWS OF RECENT LITERATURE.

GENERAL BIOLOGY.

The Rôle of Water in Growth.[1] — Dr. C. B. Davenport has made an interesting series of experiments upon the eggs and embryos of Amblystoma, toads, and frogs to determine the proportions of water relative to the other constituents of the body during the earlier stages of growth. Defining growth as "increase in volume," he finds that "exactly as in plants, there is a period of slow growth accompanied by abundant cell division — the earliest stages of the egg. There follows, after the first few hours, a period of rapid growth due almost exclusively to imbibed water, during which the percentage of water rises from 56 to 96; lastly comes the period of histological differentiation and deposition of formed substance, during which the amount of dry substance increases enormously, so that the percentage of water falls to 88 and below. But the *growth* is due chiefly to imbibed water."

Assuming for the sake of argument "that the dry substance is all growable," the author finds that the curve of daily percentage increments based on dry weights of tadpoles fails to confirm Minot's generalization that there is a "certain impulse given at the time of impregnation which gradually fades out, so that from the beginning of the new growth there occurs a diminution in the rate of growth." On the contrary, he finds in tadpoles no loss in the rate of growth of the growing substance. He points out further that no such diminution is noticeable in plants.

There are one or two points in which we would take issue with the author. In the first place, the use of the term "plasma," borrowed from the German, in place of "spongioplasm" or "reticulum" seems to us an unfortunate one. The common use of this term is to designate the fluid portion of the blood, and, therefore, when it is used in a description of the living cell-contents it conveys a false impression to English readers. In the second place, it does not seem to us to follow, because growth as a whole is shown to be due to the imbibition of water, that "we have to conclude, therefore, that all local growths are due to local imbibition of water." It is

[1] C. B. Davenport. *Proc. Boston Soc. Nat. Hist.*, vol. xxviii, no. 3, pp. 73–84. June, 1897.

well known that in tadpoles, especially, nearly all the cells are heavily laden with yolk granules until a relatively late period of development. Of this the author takes no account. It is quite conceivable that local growth might take place without any general or local increase in the percentage of water. Until the larva is able to take food the increase in the dry weight of the living material is due to assimilation of yolk, and it may be that local growth during this period is due solely to the solution, transference, and assimilation of this food supply stored within the organism. If it can be shown that there is an increase in the percentage of water in a local growth, such, for example, as a gill-bar, it may well be that it is a purely secondary phenomenon. Then the question, What determines excessive local growths? would not resolve itself into, What determines excessive local imbibition of water? but into, What determines excessive transference and assimilation of yolk material? In supposing that local growth is due primarily to the absorption of water, whether active or passive, we are assuming a simplicity of operation that is hardly warranted by the known complexity of living material.

The paper is well illustrated by tables and plotted curves.

The Capacity for Regulation in the Development of Organisms. — The word "regulation," as employed by Driesch, expresses the capacity of an organism to obliterate in development the effects of any malforming influence to which it has been subjected, so that, despite the mutilation, it develops into the normal form. Driesch's former studies had been chiefly made upon developing eggs; he now (*Arch. f. Entwicklungsmech.* Bd. v, Heft 3, 1897) examines some cases of regeneration.

As is known from the studies of Miss Bickford, regenerating stems of Tubularia do not form new tentacles by a sprouting out at the cut edge, but by a metamorphosis of the old tissue of the stem just below the cut. The old tissue thickens along a number of longitudinally lying areas representing the future tentacles, which soon become fully formed. This phenomenon of differentiation in place is called by Driesch reparation. The first question Driesch asks is: If the repairing stem be split lengthwise so that a double head is formed, will the normal number of tentacles be repaired through regulation on each half head? The result showed that nearly or quite the normal number is so formed.

Again, if the head is cut off and regenerated, and then cut off a second time, will the time elapsing before complete reformation be

less after the second cut than after the first? Experiment showed that it is so; that, whereas it takes five and one-half days on the average for regeneration to occur after the first cut, it is effected under otherwise similar conditions in three days after the second. The repetition of the stimulus quickens the response.

If a piece of the stem of Tubularia be cut at both ends, regeneration will take place at both the oral and the aboral end. If, now, in one case the oral end be sealed with wax so that it cannot grow and the aboral be left free to regenerate, will the time required for the formation of the aboral head differ in the two cases? The result showed that regeneration of the aboral head occurred in all cases inside of seven days after the cut when only one head was forming, whereas it took over twelve days when both heads were arising. Regeneration is slower when the formative stuff goes to two points than when it aggregates at only one.

The tentacles of Tubularia surround the oral end at two levels. After decapitation, consequently, reparation of tentacles occurs at two zones, a distal and a proximal. The question arises: What will happen if after reparation has begun in both zones the distal zone is cut off? Will a head with only one zone of tentacles arise? Here the marvelous phenomenon of regulation was most strikingly shown. The normal number of zones was regained, and, indeed, by either one of four modes, all producing the same end result, — the restoration of the perfect form of the adult. These four modes are: (1) by regeneration — the cut end grew out, and in this regenerated part the distal zone of tentacles arose by reparation; (2) by dissolution — the remaining (proximal) zone of tentacles was dissolved and in its place the normal condition of two zones appeared; (3) by replacement — the distal zone having been removed so as to leave the maximum space beyond the proximal zone, a new series of tentacles sometimes arose in this empty space without disturbing the proximal zone; (4) by division — the arising tentacles of the proximal zone disintegrated in their middle, forming the two zones characteristic of normal development. C. B. D.

Determination of Sex in Plants. — The causation of sex in the hemp plant, studied at various times in the past, forms the subject of a short communication in the *Comptes Rendus* of the French Academy for Nov. 15, 1897, by M. Molliard, who concludes from his experiments that the medium in which the plant grows may affect its sex, and that, in this case, contrary to the currently admitted

theory, the transformation of staminate into pistillate flowers occurs under conditions disadvantageous for the development of the vegetative apparatus. T.

Plankton Studies. — The first article of volume five of the *Bulletin of the Illinois State Laboratory of Natural History*, recently published,[1] contains a bibliography of the methods of conducting plankton studies and a useful description of the oblique haul and pumping methods which have been in successful use for some years at the Biological Station at Havana, Ill., in the collection and separation of the minute animals and plants floating free in the water and incapable of materially changing their position by their own efforts.

Students of this rather new phase of biology will also find an interesting preliminary report on the plankton of some of the lakes of the Alps and Jura[2] in the *Bulletin of the Botanical Laboratory of the University of Geneva* for June, 1897. T.

ZOOLOGY.

Cell Lineage. — In a paper entitled "Considerations on Cell Lineage, Based on a Reëxamination of Some Points on the Development of Annelids and Polyclades,"[3] Prof. E. B. Wilson presented observations regarding the origin and relations of the mesoblast in annelids and polyclades which illustrate the fact of ancestral reminiscence in cell lineage. In some of the annelids (Aricia, Spio, Nereis, and others) the primary mesoblasts have not been properly so called, for before giving rise to the mesoblast bands they bud forth cells that may be, in some cases, traced into the wall of the archenteron. In Nereis not less than six or eight such cells are formed; these become pigmented, wander into the interior, and finally give rise to the posterior part of the archenteron. In Aricia and Spio only a single pair of corresponding cells is formed, and they are so small as to play a quite insignificant part in the building of the body. A comparison of these results with those of Conklin on Crepidula

[1] Kofoid, Plankton Studies, I. Methods and apparatus in use in plankton investigations at the Biological Experiment Station of the University of Illinois.

[2] Pitard, Quelques notes sur la florule pélagique de diverses lacs des Alps et du Jura.

[3] Read before the New York Academy of Sciences, Biological Section, Dec. 13, 1897.

indicates that the mesoblastic pole cells of annelids and mollusks are to be regarded both historically and ontogenetically as derivatives of the archenteron, and that the rudimentary cells of Aricia and Spio are vestiges or ancestral reminiscences of such origin.

A reëxamination of the cell lineage of a polyclade, Leptoplana, shows that, as in the annelid or gasteropod,' all of the first three quartets of micromeres give rise to ectoblast, while the second quartet gives rise also to mesoblast, each cell of this quartet segmenting off three ectoblast cells, and then delaminating a large mesoblast cell into the interior. The third quartet apparently gives rise to ectoblast alone, though the possibility of its producing mesoblast is not excluded. The four macromeres remaining give rise to the archenteron, as Lang describes, first dividing to form four basal cells (corresponding in origin and position with the four basal entomeres of annelids and mollusks) and four much larger upper cells which correspond to the fourth quartet of micromeres in annelids and mollusks. The posterior of these cells always divides before the others, sometimes equally and symmetrically, as in Discocoelis (Lang), but more often unequally. The cells thus formed give rise to a part of the archenteron, and not, so far as can be determined, to mesoblast.

These observations show that the mesoblast of polyclades is of ectoblastic origin, and they suggest that the origin of mesenchyme cells from the second (Unio, Crepidula) or third (Physa, Planorbis) quartets in gasteropods may be a vestige or ancestral reminiscence of the mesoblast formation in the polyclades. They suggest, further, that the mesoblast bands (entomesoblast) of annelids and mollusks may have been historically of later origin than the mesenchyme (ectomesoblast) — a view which harmonizes, broadly speaking, with that of Meyer — and that the two symmetrical entoblast cells into which the posterior member of the fourth quartet divides in the polyclade may represent the prototypes of the entomesoblasts of the annelids and gasteropods.

Early Stages in the Development of Molgula. — Mr. Crampton briefly reviewed his observations on the early history of the egg in *Molgula manhattensis* as follows:[1]

The author emphasized the fact that development begins not with the cleavage or fertilization processes, but even before. From the origin of the primary oöcyte until the final assumption of the adult

[1] Paper read before the New York Academy of Sciences, Biological Section, Dec. 13, 1897.

form, there is a continuous series of developmental changes, each stage being based upon the preceding one and conditioned by it.

The growth of the primary oöcyte and the formation of the yolk were considered at some length. A true "yolk nucleus" arises, as the author believes, from the nucleus, and this by continued growth, and later by fragmentation, gives rise to very small spherules, which later, by enlarging, form the yolk spherules. The yolk nucleus is an albuminous body closely allied to, if not identical with, the yolk or deutoplasm. This was indicated by a large number of microchemical tests. The yolk nucleus at a very early stage of the egg was also shown to be the only albuminous body in the cell; for the rest of the extra-nuclear part of the cell is almost exclusively composed of pseudo-nucleinic substances. Evidence was cited which indicated that the yolk nucleus was formed by the nucleus, and that it enlarged by constant additions to it from the nucleus.

The more important results of a study of the maturation and fertilization processes might be briefly stated, although a fuller account will appear in the published paper. The first maturation spindle arises entirely from the germinal vesicle. It is peculiar in that it is barrel shaped, and does not, as far as can be determined, bear at either end centrosomes or asters. The first polar body receives sixteen chromosomes, while sixteen remain in the egg. The second maturation spindle is also barrel shaped, and is also devoid of centrosomes and asters. Eight chromosomes remain in the egg. The sperm entrance was described in detail, and evidence was brought forward to show that the centrosomes of the first cleavage figure were derived from the sperm.

The spindle of the first cleavage figure appears to be formed from the segmentation nucleus, there being no 'central spindle' extending between the centrosomes. The spindle itself was shown to be barrel shaped, the daughter chromosomes reforming into a vesicular nucleus at the ends or heads of the barrel. A "Zwischen-Körper" also arises, as in the maturation stages, by a concentration of the spindle fibers at the equator of the figure. After the reformation of the daughter nuclei, and after division of the cell body, the paired daughter centrosomes and asters diverge. The daughter nucleus later moves up between the asters, and prepares for the next division. Comparative independence and parallelism of the processes undergone by the centrosomes and asters, on the one hand, and those of the nuclei, on the other, become very strongly probable. Detailed evidence in support of the above points will be given in the published paper, a preliminary notice.

Zoology at Johns Hopkins. — The number of the *Johns Hopkins University Circular* for November, 1897, is devoted to accounts of biological work done. In the introduction Prof. W. K. Brooks gives an outline of the work of the Jamaica expedition of 1897. Dr. H. L. Clarke's paper on the *Viviparous Synoptidæ* of the West Indies is reprinted from the *Zoologischer Anzeiger*. Prof. Maynard M. Metcalf discusses the follicle cells in Salpa, in which he supports the earlier results of Brooks. Dr. George Lefevre has a paper on "Budding in Ecteinascidia." In this form the bud development is strikingly like that in Perophora, as described by Ritter, except for the peculiar rotation of the inner vesicle, which complicates the process in that genus. Dr. F. S. Conant describes one new genus (Tripedalia) and two new species of Cubomedusæ (*T. crystophora* and *Charybdea xaymacana*). The paper is more than systematic, for it contains notes upon the anatomy and development. We understand that Dr. Conant's notes and drawings made during the past summer have been preserved and will be included in the full paper, to be published later. Mr. Gilman A. Drew has some interesting notes on the embryology of the primitive mollusk Yoldia. The most important features in the development are the formation of a larval test, only paralleled by that of Dondersia and the formation of the central ganglia from the walls of invaginations. Dr. E. A. Andrews describes some spinning activities of the polar globules in echinoderms, mollusks, and nemertines, phenomena to which attention has but recently been called.

BOTANY.

Botanical Observations on the Azores,[1] by William Trelease. — During the summers of 1894 and 1896 Professor Trelease, Director of the Missouri Botanical Garden, made two excursions to the Azores. By his friends it was generally supposed that these journeys were rather in the nature of well-earned vacation trips of a man whose productive research work and arduous executive duties must call for occasional relaxation. It is accordingly a matter of some surprise to see as a result of these trips a stout, closely printed, and excellently illustrated report, including not only a careful compilation of the work of others, but hundreds of entries of

[1] From the *Eighth Annual Report of the Missouri Botanical Garden*, issued Sept. 9, 1897.

personal observations. Of this report the introductory pages give a concise statement of the geography, geology, and meteorological conditions of the archipelago, followed by a habital description of the vegetation, including not only the gradually disappearing indigenous element and numerous introduced species, but even the varied plants of cultivation.

The body of the report is occupied by a complete enumeration of the plants, both phænogamic and cryptogamic, known to grow naturally upon the islands. In this list, the following classes of plants are distinguished by different kinds of type: (1) endemic species, (2) Atlantic species of wider distribution, (3) established escapes, (4) doubtful or casual plants. Even the relative abundance of the different species is indicated by signs, so that their respective importance in making up the entire vegetation can be readily inferred. After the names of each species and variety are enumerated the islands on which it occurs, various authenticated *exsiccati*, and several references to the most accessible descriptions and figures. The nomenclature of the Kew Index has been followed "as a matter of convenience." — Would that some other American botanists could be content to follow this example and at the same time consult both their own convenience and that of their colleagues! — Some half-dozen new species and varieties of phænogams are characterized, and these, as well as a number of other rare and hitherto unillustrated endemic species, are admirably figured in fifty-four plates, drawn by Miss Grace E. Johnson.

Professor Trelease has sought in vain for evidence of that racial and varietal divergence in the florulæ of the different islands which is so pronounced in the Galapagos Archipelago. This fact, however, is not very surprising. Such a divergence could scarcely come about unless the florulæ were to a considerable extent isolated; for, if this were not the case, there would be constant crossing and reblending of nearly related forms. In the matter of isolation of the different islands, the Azores and the Galapagos Archipelago are in no sense similar. As Wallace has pointed out, the meteorological conditions for seed distribution are much more favorable in the Atlantic than in the Pacific. But a still more important difference lies in the long habitation of the Azores and constant human intercourse between the different islands of the group. This cannot have failed to bring together plants which have tended toward racial divergence, and these when established upon the same island have most likely crossed freely and again formed a common stock.

The carices of the list, so far as represented by the collections of Professor Trelease, have been identified by Prof. L. H. Bailey, and the cellular cryptogams by a number of specialists. At the close of the paper is a generic index and a bibliography of Azorean botany. The whole report is not only a great credit to its author, but forms the most noteworthy piece of recent American work upon any extra-American flora. B. L. R.

The Flora of British India. — With the publication of the title-page and preface of the seventh volume, and a full index (collated with the *Index Kewensis*) to the entire work, *The Flora of British India*[1] is brought to a close at the end of 1897. In the quarter of a century consumed in its publication the area to which it is devoted has materially increased, and many new collections have been brought to the hands of its indefatigable editor and his collaborators, so that it is but natural that the later volumes should be more thorough than the earlier ones. Valuable it is, throughout; and yet, as Dr. Hooker remarks in the preface to the concluding volume, the treatise is to be regarded as a pioneer work rather than a finished flora. There is no reason to doubt, however, that time will justify his very modestly expressed hope that it may not only enable botanists to name with some accuracy a host of Indian plants, but that it may further facilitate the compilation of local floras and monographs and the discussion of the problems of the distribution of plants from the point of view of what he very well characterizes as perhaps the richest and certainly the most varied botanical area on the surface of the globe, and one which, in a greater degree than any other, contains representatives of the floras of both the Eastern and Western Hemispheres. T.

Miss Eastwood's Studies.[2] — In the second part of the recently inaugurated botanical section of the *Proceedings of the California Academy of Sciences*, Miss Eastwood gives interesting information concerning a number of plants from the White Sands of New Mexico; a comparative study of spurless forms of Aquilegia, in

[1] *The Flora of British India.* By Sir J. D. Hooker, assisted by various botanists. London. L. Reeve & Co. Pts. xxiii and xxiv. Price 18s. net. — The dates of publication of the volumes, as follows: i, May 1872–Feb. 1875; ii, May 1876–May 1879; iii, May 1880–Dec. 1882; iv, June 1883–Aug. 1885; v, Aug. 1886–Apr. 1890; vi, Dec. 1890–Apr. 1894; vii, 1896–1897.

[2] Alice Eastwood, Studies in the Herbarium and the Field. No. 1. *Proc. Calif. Acad. Sci.* 3 ser. Botany, i, No. 2, 71–86. Pl. VI, VII.

which several nominal varieties of this character are described; descriptions of new Californian species belonging to the genera Iris, Montia, and Newberrya; and a revision of the Manzanitas of Mt. Tamalpais, in which, because of the inadequacy of printed descriptions and other difficulties, three forms that seem undescribed are described and named as distinct species, while it is left to some future monographer of the genus to assign "definite limits, if that be possible in so polymorphous a genus, which continually suggests hybridization or a very active and unlimited tendency to vary."

T.

Pittonia. — In the seventeenth part of volume three of this work,[1] which appears at irregular intervals, Professor Greene writes on new species of Eriogonum; the hop trefoils, for which he takes up Desvaux's name Chrysaspis; a second list of corrections in nomenclature, in which he takes up Necker's name Aragallus for a large number of leguminous plants usually known as Oxytropis or Spiesia; a nineteenth instalment of "New or Noteworthy Species," dealing likewise largely with Leguminosæ; on the classification of asclepiads, in which the genus Oxypteryx is proposed for *Asclepias arenicola* Nash, and Podostemma for certain other species clustering about *Asclepias longicornu* Benth.; the genus Chamæcrista, first established by Commelin in 1697, and of which, fortunately, considering their recent multiplication, no species are characterized as new, though nine are transferred from their familiar association with Cassia; a sixth part of "Studies in the Compositæ" devoted to a discussion of the following new and restored genera: Leucosyris, Leucelene, and Ionactis, the latter based on *Aster linariifolius* L., *Chrysopsis alpina* Nutt., and *A. stenomeres* Gray; a twentieth instalment of "New or Noteworthy Species," well distributed over the Polypetalæ and Gamopetalæ; a second series of "Studies in the Cruciferæ," in which the genus Nesodraba is proposed for several species of the Alaskan region, previously referred to Draba or Cochlearia; and "Notes on Violets," accompanied by three plates illustrating *Viola emarginata.* T.

Cell or Corpuscle? — Under this title, in *Natural Science* for December, 1897, Rudolf Beer discusses the much-vexed question of the terminology of those structural units which are yet organisms rather than the ultimate units of organs. Concluding that in vege-

[1] *Pittonia.* A series of botanical papers by Edward L. Greene. Washington, September–December, 1897. Price, 50 cts.

table anatomy either the wall or the living contents of the so-called cell must be renamed, he would retain the name cell for the former, designating the cytoplasm and nucleus as a corpuscle, believing that in this way botanical and zoological terminology may be brought into harmony most readily.

The Septate Leaves of Dicotyledonous Plants. — M. John Briquet, in the *Bulletin of the Botanical Laboratory of the University of Geneva*, for June, 1897, gives an interesting summary of his recent studies on certain of the plants possessing the foliar septa first recorded by Guettard in 1747, and for many monocotyledous genera and the single dicotyledonous genus Villarsa, examined in detail by Duval-Jouve in 1873. To these M. Briquet now adds species of the umbelliferous genera Ottoa, Crantzia, and Tiedemannia. With Duval-Jouve, he concludes that the diaphragms or septa serve to increase considerably the solidity of construction of the leaf without interfering with the free circulation of gases in its intercellular spaces. While the majority of plants possessing these structures are aquatic or subaquatic, *Tiedemannia teretifolia* is shown to be amphibious and to possess admirable adaptations to existence during alternating periods of extreme wet and drought. T.

The Photosynthetic Organs of Asparageæ. — Though, as is too frequently the case with students of vegetable anatomy, Professor Reinke has no thought of a monograph of this interesting group, his recent study of the cladodia of Asparagus, Ruscus, Danæ, and Semele [1] contains much that is of interest to the systematist, and justifies the conclusion that these aberrant genera are really derivatives of the leafy Siliaceæ. T.

New Hardy Nymphæas. — In the *Revue Horticole*, of Paris, for Nov. 16, 1897, M. André describes three new hardy Nymphæas of the odorata type, — *N. gloriosa*, *N. Ellisiana*, and *N. odorata exquisita*, — which have recently originated as seedlings under the hands of M. Latour-Marliac, whose beautiful seedlings and hybrids of American pond lilies are now known wherever this attractive class of aquatics is cultivated. T.

Flora of Africa. — To the many recent publications on the African flora is now added a list in which the botanists of the Brussels Garden propose to publish rapidly the new species and interesting facts brought out in the examination of the collections they are now

[1] Reinke, Die Assimilationsorgane der Asparageen. Eine kritische Studie zur Entwickelungslehre. *Jahrbücher f. wiss. Bot.*, Bd. xxxi, Heft 2, 207–272, f. 26.

receiving. The first fascicle,[1] just issued, adds one hundred and fifteen species to the known flora of the Congo, and describes twenty as new to science. T.

Proprietary Rights in Science. — Another incident in the history of the Rouy and Foucaud *Flore de France*, given to the curious reader by M. Malinvaud in the *Journal de Botanique* of October 19, opens a question of general ethics in scientific citation. It appears that in the flora named a Dentaria is ascribed to a certain region on the authority of two persons, one of whom is one of the authors of the book, while it is now shown that some eighteen years ago the plant was found and first recorded for that locality by others. The author in question claims that his custom has been to cite specimens seen by himself in the course of his study. His critic evidently contends for the citation of the original discoverer. The practice of the more thorough American botanists would lead one to believe that possibly either party in the present instance is little more than half right, with the balance slightly in favor of the author who has actually seen the specimen on which an entry is made. T.

The November number of the *Johns Hopkins University Circulars* contains, in abstract, a paper by D. S. Johnson, on the leaf and sporocarp of Marsilia.

A sad chapter in the history of American biology is supplied by Professor Brooks's notes on the Johns Hopkins expedition to Jamaica in the summer of 1897, in the *Johns Hopkins University Circular* for November, and the memorial minutes, in the same number, accompanied by biographical sketches of James Ellis Humphrey and Franklin Story Conant. These promising biologists, the former already well known in botanical circles, and the latter coming to the front in zoology, fell victims to the ever-present fever of the tropics, and it may well be asked if their death should not suggest more care than has usually been given in the organization of expeditions for scientific exploration where such diseases are likely to occur.

Students of human nature who have observed the punctiliousness with which the *Monsieur de's* in the reign of terror inscribed themselves as *Citoyens* will find some entertainment and no small food for reflection in an article by Dr. Alfred Chabert on the well-known botanist Villars, published in number ten of the *Bulletin of the Boissier Herbarium* for 1897.

[1] Durand and de Wildeman, Matériaux pour la flore du Congo. Premier fascicule. *Bull. Soc. Roy. de Bot. de Belgique*, tome xxxvi, pp. 47–97, pl. III–VI.

PALEONTOLOGY.

Harris's Catalogue of Australasian Tertiary Mollusca.[1] — The catalogues published by the trustees of the British Museum generally contain much more than their titles imply. In them will often be found some of the latest applications of the laws of evolution and the elucidation of new and important principles of morphology. Discussions of this nature have added value and weight from the intimate association of specimens and ideas, for usually curators of collections and custodians of ideas are too frequently dissociated. It is, therefore, a wise policy to engage the services of the highest talent in the preparation of the catalogues or reports on various collections or classes of organisms.

Thirteen volumes on fossil vertebrates, eight on fossil invertebrates, and three on fossil plants have already been published in this series, and Dr. Woodward states that thirty volumes more will be needed to include the remainder of the plants and Mollusca, the whole of the Brachiopoda, Annelida, Arthropoda, Echinodermata, and Cœlenterata.

The present catalogue of the Tertiary Mollusca of Australasia is based upon the study of large collections, especially rich in well-preserved Gastropoda. Mr. Harris has thus been enabled to study the larval shells and the stages of growth with accuracy and precision. In studies of phylogenies and in the systematic classification of the Gastropoda the results are important. The scaphopods and lamellibranchs are also included, but owing to meager material they have afforded insufficient data for general conclusions.

Some valuable suggestions are given governing the correlations of phylogeny with chronology. Thus, a genus that has survived from early Mesozoic times, with but little modification in the later stages of its history, has had its day and settled down to a more or less fixed form. Such a genus is of little use for homotaxial purposes, though interesting phylogenetically. In the Tertiary the determination of homotaxis can best be based upon families which originated in Jurassic or Cretaceous times and reached the Eocene with strong tendencies to variation ; yet, at the same time, the members should be capable of wide and rapid dispersion.

[1] Catalogue of the Tertiary Mollusca in the Department of Geology, British Museum (Nat. Hist.). Pt. i. The Australasian Tertiary Mollusca. By George F. Harris, F.G.S. 8vo, pp. i–xxvi, 1–407. Pl. I–VIII. London. Printed for the trustees. 1897.

The general law is suggested that when the main features of ornament are foreshadowed in the early nepionic or brephic stage, and especially when they obtain even in the protoconch, that ornament may be regarded as of value in the determination of species. On the contrary, when the ornament does not make its appearance until the late neanic or adolescent stage, and, even in an elementary sense, is not completed until what may be regarded, by analogy, as the early mature stage, that ornament merely characterizes the individual, and is only of negative use for the purposes of classification.

As is well known, the size of the protoconch is variable, even in the offspring of a single individual, that difference being commonly attributed to carnivorous proclivities on the part of the larger specimens when in the embryonic stage. The author also notes that the size of the protoconch does not seem to have much influence in determining the size of the shell in the adult. The larger protoconch is not very often accompanied by the production of a larger adult shell than that which comes from a much smaller protoconch, that is, in the same species. There are, however, exceptions to this, and, correlatively, it may be noted that the shape of the protoconch occasionally determines the general shape of the shell.

Further interesting observations are made on the development of the Volutidæ, the columellar plications in Mitra, and the recurrence of a type of ornamentation in a species of Cerithium. All the genera are briefly described, and the type species is given. The notes on the species are preceded by a list of the synonymy and bibliographic references.

Some changes in the nomenclature of the genera will not meet with general endorsement, although the principles adopted are, for the most part, those approved by the best authorities. Thus, the name Nuculana (Link, 1807) is used instead of Leda (Schum., 1817) on the ground of priority. Nuculana, however, was given by Link as a mere verbal substitute for Nucula (Lam., 1799), as Dr. W. H. Dall and others have shown. Link's diagnosis applies to Nucula and not to Leda, for he says that the shell is "smooth, closed all round." Nuculana (Link *non* Adams) is therefore "an exact synonym" of Nucula, and cannot be sustained on the ground of priority. Consequently the family name Nuculanidæ, Adams, cannot be retained for Ledidæ.

C. E. B.

PETROGRAPHY.

California Eruptive Rocks. — The "bed-rock" series of the Sierra Nevadas underlying the sands, gravels, and volcanic rocks in the vicinity of Nevada City and Grass Valley, Cal., consists of highly altered sedimentary rocks, crystalline schists, and igneous rocks, much resembling pre-Cambrian complexes elsewhere, but which here are known to be much younger than Cambrian.

Lindgren[1] describes the old igneous rocks as comprising granodiorite, a type of rock intermediate between granite and quartz, — mica-diorite, aplite, granite-porphyry, diorite-porphyrite, diorite, gabbro, serpentine, diabase, porphyrite, augite-syenite, and amphibolite. The limits of variation of the granodiorite are shown by the following figures :

SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O
59–68.5	14–17	1.5–2.25	1.5–4.5	3–6.5	1–2.5	1–3.5	2.5–4.5

Its predominant feldspar is a plagioclase, though orthoclase is present in small quantities, often intergrown with albite forming micro-perthite.

The gabbros are distinguished from the diorites by the character of their feldspathic component. This is a mediumly acid variety in the diorites and a basic variety in the gabbro. The ferromagnesian constituent in the latter rock may be either pyroxene, hornblende, or mica; though, as a matter of fact, all the gabbros described by the author contain some form of pyroxene or its alteration product. The serpentine is derived from pyroxenite and peridotite.

The diabases and porphyrites probably represent the cores of old volcanoes. These rocks grade into each other through so many different types that the author finds it difficult to classify them. The principal distinction made use of in defining them appears to be coarseness of grain, "since the diabase may readily become porphyritic, the resulting rock being referred to as diabase-porphyrite. A more pronounced porphyritic structure with finer-grained holocrystalline groundmass gradually leads over into the porphyrites, referred to as augite-porphyrites or hornblende-porphyrites." A majority of the porphyrites might be classed as apo-andesites, though the rocks are very different from the andesites of the district.

[1] *Seventeenth Annual Report of the U. S. Geol. Survey*, vol. ii, p. 2. Washington, 1896.

The amphibolites are "massive or schistose rocks composed chiefly of hornblende, usually with smaller quantities of quartz, feldspar, epidote, and chlorite." They are in most cases dynamically metamorphosed diabases or porphyrites.

The sedimentary rocks of the district are siliceous argillites, clay-slates, quartzites, and micaceous schists. These are altered by both dynamic and contact metamorphism.

The metamorphic processes, excluding weathering, are divided into: (1) dynamic metamorphism, including dynamo-chemical metamorphism, as in the case of the formation of amphibolites from diabases; (2) common hydro-metamorphism produced at low temperatures; (3) hydro-thermal metamorphism, including solfataric metamorphism, and (4) contact metamorphism. The most important characteristic of dynamo-chemically metamorphosed rocks is the production of mosaics. Feldspars are among the most important of the new minerals formed by this process. In hydro-metamorphism the original constituents of rocks are broken down into aggregates with the production mainly of hydrated minerals.

In his discussion of the gold-quartz veins the author calls attention to the fact that the wall rocks of the veins have been much altered by metasomatic processes. The changes effected in them consist mainly in the introduction of carbon dioxide, sulphur, and potassium and the abstraction of silica and sodium. The changes produced in a granodiorite by these processes have resulted in a new rock composed of: sericite $= 61.11\%$, quartz $= 25.00\%$, sphene $= .60\%$, apatite $= .46\%$, pyrite $= 2.87\%$, $FeCO_3 = .58\%$, $MgCO_3 = 2.70\%$, and $CaCO_3 = 7.23\%$. A siliceous argillite, originally consisting of a fine-grained aggregate of quartz, feldspar, brown mica, pyrrhotite, and organic matter, has been changed to an aggregate of sericite, calcite, and residuary quartz. The principal results of the interaction of the wall rock of the veins and the liquids emanating from the vein fissures are thus seen to be carbonates and sericite.

The Rocks of Castle Mountain, Mont. — The Castle Mountain mass in Central Montana is an eroded volcano, which presents "all the different types of crystallization and structure possible for an igneous magma to assume under the most varied conditions of cooling and pressure." In general, the rocks have been derived from a siliceous magma rich in alumina and the alkalies. This has given rise to the various members of the granite-rhyolite family in the district. Associated with these, but in much smaller amounts, are

found augite-diorite, porphyrites, lamprophyres, and basalts. These are arranged as follows: plutonic rocks in the central core, porphyritic rocks in intruded sheets and dikes, extrusive rocks in lava flows, and tuffs and breccias underlying the lavas. All these different rocks are described in detail by Weed and Pirsson.[1] The plutonic rocks are granite and augite-diorite. They have altered the shales through which they intrude into tough hornstones, and the limestones into coarsely crystalline marbles containing in places garnet, phlogopite, vesuvianite and pyroxene.

The naming of the rock types discussed by the authors is based on their macroscopic texture. In the acid series, for instance, those rocks are called granite which appear holo-crystalline to the naked eye. Those are named quartz-porphyry which possess a groundmass so finely granular that its components cannot be distinguished without the aid of a microscope, and those that contain glass or a very dense groundmass are called rhyolite. In their description of the granite-porphyry the authors describe the micro-pegmatitic structure as an original one and express doubts as to its ever being secondary. Dark basic concretions in the granite are regarded as the result of the liquation of the liquid magma from which the rock solidified. One of the most interesting of the quartz-porphyries described is a rock containing sufficient tourmaline to rank as an accessory component. This mineral occurs in stellate groups replacing feldspar. Very frequently fluorite is associated with it. An analysis of this rock gave:

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	K_2O	Na_2O	Li_2O	KH_2O	Total
74.82	.25	13.80	.37	.30	tr.	10.	.17	4.81	4.33	tr.	.83	= 99.78

The lamprophyres cutting the "belt series" of shales, etc., are augite, — vogesites, minettes, monchiquites, and diabases. Many of the rhyolites are devitrified and many of them contain spherulites. These are thought in all cases to be original.

A comparison of the analyses of the different rock types of this district shows that no absolute relation exists between the silica and the different bases; but it seems to indicate that there is a definite relation between the quantities of soda and potash present. The differentiation of the Castle Mountain series appears to have been deep-seated.

The igneous rocks of the Denver Basin, Colorado, are principally basalts, which appear on the plains at the foot of the mountains as dykes and surface flows or sheets. Augite-syenite and quartz-

[1] *Bulletin 139 of the U. S. Geol. Survey.* Washington, 1896.

porphyry also occur in the district, but in small quantity only. All the basalts contain orthoclase in fairly large quantity. An analysis of the rock from a dyke at Valmont gives:

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	BaO	MgO	K_2O	Na_2O	P_2O_5	Cl	SO_3	H_2O	Total
48.25	.89	16.73	3.99	6.28	8.32	.013	5.77	4.08	3.24	.68	.08	.12	1.72	=100.163

The augite-syenite is a biotitic variety containing some bronzite.

The tuffs occurring in the district are andesitic. These and certain andesitic pebbles found in conglomerates are the only evidences met with in the study of the district that point to the former presence of andesite lavas in the vicinity.[1] W. S. B.

[1] W. Cross, Ch. V. Geology of the Denver Basin in Colorado. Monograph XXVII. *U. S. Geol. Survey*, p. 315.

Sir William Flower has resigned the presidency of the International Zoological Congress. Sir John Lubbock has accepted the office, and will preside at the meeting at Cambridge next August.

In a recent number of this journal we gave an outline of several expeditions of the summer of 1897. In addition to those there noted must be added the botanical expedition of Mr. J. M. Rose to Mexico. Lower California, the west coast of Mexico, and the states of Zacaticas, Durango, and Jalisco were explored, and the collections brought back contained 2000 numbers. Mr. A. P. Morse, who is connected with Wellesley College, visited the Pacific coast under the direction of Mr. S. H. Scudder, and made large collections of insects and especially of Orthoptera.

At the meeting of the Academy of Science of St. Louis, on the evening of January 3, the following officers for 1898 were installed: President, Edmund A. Engler; Vice-Presidents, Robert Moore and D. S. H. Smith; Recording Secretary, William Trelease; Corresponding Secretary, Joseph Grindon; Treasurer, Enno Sander; Librarian, Gustav Hambach; Curators, Gustav Hambach, Julius Hurter; Directors, M. H. Post, Anand Ravold.

Prof. R. A. Philippi has resigned the directorship of the National Museum at Santiago, Chili, on account of his age (90 years). He has held the position for 43 years. He is succeeded by his son.

The Department of Agriculture has decided to abandon the subtropical laboratory maintained for several years past at Eustis, Florida. We are not in a position to judge of the economic results of the laboratory, but its scientific production has been such as to make its abandonment a matter of regret.

Dr. Harrison Allen died in Philadelphia November 14. He was born in that city April 17, 1841, studied medicine in the University of Pennsylvania, served as assistant surgeon in the United States Army during the Civil War, and in 1865 was appointed professor of comparative anatomy in his *Alma Mater*, a position which in 1878 was changed to the professorship of physiology. Dr. Allen was a careful and accurate anatomist, and his papers on the anatomy of mammals and the systematic descriptions of the Chiroptera are of great value. Personally, Dr. Allen was a delightful companion, and his death, with that of Drs. Horn and Cope, is a severe loss to science, not only in Philadelphia, but in America as well.

Vesuvius is active again, throwing forth ashes and lava from the central crater, and much more from the lower crater called Atrio del Cavallo.

The Northumberland Sea Fisheries Committee and the Durham College of Science have opened a marine biological laboratory at Cullercoats, near Newcastle. Mr. Meek has been placed in charge of the scientific work.

The Berlin Academy of Sciences has granted 3000 marks to Prof. B. Hagen, of Frankfurt, for the publication of an anthropological atlas, 1500 marks to Professor Kohen, of Griefswald, for mineralogical researches, and 800 marks to Prof. R. Bonnet for anatomical studies.

The *Johns Hopkins University Circular* for November, 1897, contains sketches of the late Prof. James Ellis Humphrey and Dr. Franklin Story Conant.

The Annual Report of the Australian Museum at Sydney contains the statement that the Museum has recently acquired the remains of the elephant "Jumbo." Be it known to our antipodal friends that the great and only Jumbo — the Jumbo of the London "Zoo" — is preserved in the United States, his skeleton in the American Museum in New York City, his skin in the Barnum Museum of Tufts College. The Australian Jumbo is but a pretender.

In his admirable address as president of the British Malacological Society, Prof. G. B. Howes has the following extremely pertinent remarks: "One regrettable feature of the year's work has been the tendency toward reversion to the trinomial system and the too rigid adherence to rules of priority. When, in an age in which science is popular, Aplysia becomes Tethys and *vice versa*, and, in one of overcrowding of literature, it is thought desirable to discriminate between 'types,' 'paratypes,' and other sort of types, it were no wonder did the wayside naturalist turn from us in despair. For the purists Ichthyosaurus ought to go, Troglodytes becomes Anthropopithecus. Convenience and fitness of things must be considered. The effects of extreme specialization are here but too evident; one man describing as the result of a life's labor 'characters' which it requires the experience of a life to appreciate. If this course is to continue, let us boldly replace *Homo sapiens* by *Mendax simplex* and have done with it."

Recent appointments: Dr. Gustav von Arthaber, docent in paleontology in the University of Vienna. — W. L. Bray, professor of botany in the University of Texas. — Edgar R. Cummings, instructor in geology in the University of Indiana. — Dr. Eugen Czaplewski, director of the bacteriological laboratory in Cologne. — Dr. O. V. Darbishire, docent in botany in the University of Kiel. — W. L. H. Duckworth, lecturer upon anthropology in the University of Cambridge. — Dr. H. Eggeling, assistant in anatomy in the University of Würzburg. — Dr. S. Fuchs, extraordinary professor of physiology in the University of Jena. — Dr. Otto Fuhrmann, of Geneva, extraordinary professor of zoology at the Academy of Neuchatel. — Dr. Thaddaeus von Garbowski, docent in zoology in the University of Vienna. — Dr. Geo. T. Kemp, professor of physiology in the University of Illinois, Urbana, Ill. — Prof. Gregor Kraus, professor of botany in the University of Würzburg. — Dr. Kreidl, docent in physiology in the University of Vienna. — Dr. Lehmann-Nitsche, chief of the section of anthropology in the Museum of La Plata. — J. G. Luehman, government botanist at Victoria, Australia. — Dr. Alexis Alexander Ostroumoff, professor of zoology in the University of Kazan, as successor of Professor Melnikow. — Dr. Gustav Piotrowski, docent in physiology in the University of Lemburg, Austria. — Dr. Ludwig Plate, titular professor of zoology in the Veterinary School at Berlin. — Dr. Hans Rahl, docent in histology in the University of Vienna. — Herbert M. Richards, instructor in botany in Columbia University. — Dr. Guido Schneider, director of the biological station at Sebastopol. — Dr. William G. Smith, lecturer in botany in Yorkshire College, Leeds, England. — Dr. Julia Snow, instructor in botany in the University of Michigan. — Dr. A. A. Tylor, instructor in biology in Union College. — Dr. Franz Wagner, professor extraordinary of zoology in the University of Giessen.

Louis V. Pirsson, of New Haven, has been appointed professor of physical geology in the Sheffield Scientific School of Yale University, *not* at Harvard, as we stated erroneously in our January number.

Recent deaths: Samuel Allport, petrologist, in Birmingham, England, July 7, aged 81. — Leopold Auerbach, professor of physiology in the University of Breslau, September 30, aged 69. — James Bateman, botanist and author of monographs upon Odontoglossum and upon the orchids of Mexico and Guatemala, at Worthington, England, November 27, aged 86. — Peter Bellinger Brodie, well known for his work on fossil insects, at Rowington, England, November 1, aged

81. — Dr. Louis Calori, formerly professor of anatomy in the University of Bologna. — Dr. Cesare Crety, professor of zoology and comparative anatomy in the University of Sassari, Sardinia, September 14. — Joseph William Dunning, entomologist, in London, October 15. — Prof. Raphael von Erlanger, zoologist, at Heidelberg, aged 33. — Dr. J. Frenzel, zoologist, in charge of the Müggelsee Biological Station near Berlin, aged 39. Dr. Frenzel spent several years in South America, and did much work upon the invertebrate fauna. — Ernest Giles, an Australian explorer. — Francisque Guillebeau, a student of Coleoptera, at Le Plantay, France, August 17, aged 76. — Dr. M. Forster Heddle, mineralogist, St. Andrews, Scotland, November 19, aged 69. — Dr. Samuel Houghton, for thirty years professor of geology in Trinity College, Dublin, October 31, aged 76. — Dr. Nikolaus Kleinenberg, professor of comparative anatomy in the University of Palermo, well known for his researches on Hydra and on the development of annelids. — Prof. Alessandro Lanzillotti-Buonsanti, a student of the anatomy of domestic animals, at Milan, September 10, aged 40. — August Merkel, student of Coleoptera, in Brooklyn, August 19, aged 60. — Samuel A. Miller, well known for his work upon paleozoic invertebrates, at Cincinnati, December 19, aged 61. — Dr. Wilhelm Mörike, docent in geology in the University of Freiburg, and known from his studies of the geology of South America. — Alberto Perugia, ichthyologist, in Genoa, September 24, aged 54. — Johann Schaschl, coleopterist, at Unterburg, Austria, September 26. — Dr. A. Schrauf, professor of mineralogy in the University of Vienna, aged 60. — Dr. Friedrich Wilhelm Snyder, botanist, at Braunsberg, Prussia, aged 87. — Rev. Gustav Standfuss, student of Lepidoptera (father of Max Standfuss), October 6, aged 82. — Dr. Otto Volger, mineralogist and geologist, in Sulsbach, October 18, aged 75. — Capt. E. Y. Watson, student of Lepidoptera, in India.

BOOKS RECEIVED.

ANDREWS, GWENDOLEN FOULKE. — The Living Substance as such: and as Organism. Boston, Ginn, 1897.

ACLOQUE, A. — Faune de France. Paris, Baillière, 1897.

BAILEY, L. H. — Principles of Fruit Growing. New York, Macmillan (Rural Science Series), 1897. $1.25.

BRITISH MUSEUM (Natural History). — Catalogue of Tertiary Mollusca, Part I, Australasia. London, 1897.

EIMER, THEODORE. — On Orthogenesis and the Impotence of Natural Selection in Species-Formation. Chicago, Open Court Pub. Co., 1898. 25 cents.

GEIKIE, SIR ARCHIBALD. — The Founders of Geology. London and New York, Macmillan, 1897. $2.00.

GOODE, GEORGE BROWN. — The Smithsonian Institution. 1846–1896. The history of the first half-century. Washington, 1897.

KINGSLEY, J. S. — Elements of Comparative Zoology. New York, Holt, 1897. $1.20.

INGERSOLL, ERNEST. — Wild Neighbors, Outdoor Studies in the United States. New York, Macmillan, 1897. $1.50.

IOWA GEOLOGICAL SURVEY. — Annual Report, 1896, with accompanying papers. Des Moines, 1897.

MACH, ERNST. — Popular Scientific Lectures. Trans. by J. T. McCormack. 2d edition. Chicago, Open Court Pub. Co., 1897.

MORLEY, MARGARET WARNER. — A Few Familiar Flowers. Boston, Ginn, 1897. 70 cents.

MORLEY, MARGARET W. — Flowers and Their Friends. Boston, Ginn, 1897. 60 cents.

MISSOURI BOTANICAL GARDEN. — Eighth Annual Report. St. Louis, 1897.

RANDOLPH, HARRIET. — Laboratory Directions in General Biology. New York, Holt, 1897. 80 cents.

ROBINSON, LOUIS. — Wild Traits in Tame Animals, being some familiar studies in evolution. Edinburgh, Blackwood, 1897.

ROMANES, GEORGE JOHN. Darwin and after Darwin III, Post-Darwinian Questions, Isolation and Physiological Selection. Chicago, Open Court Pub. Co., 1897. $1.00.

ROTH WALTER E. Ethnological Studies among the North-west-central Queensland Aborigines. Brisbane, Government, 1897.

TROUESSART, E. L. Catalogus mammalium tam veventium quam fossilium. Nova edite. Fasc. III, Rodentia II. Berlin, Friedländer, 1897. 10 marks.

LOUIS AGASSIZ.

From a photograph kindly lent by Professor Burt G. Wilder

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LOUIS AGASSIZ.

Two extensive accounts of the life of Louis Agassiz have already been written, one from the hands of Mrs. Agassiz, the revered president of Radcliffe College, the other by his life-long friend Jules Marcou. We have no intention of preparing a third, nor do we expect to throw new light upon the subject. We only offer an outline of his life merely as an introduction to the following articles, which deal with some of the special studies of the great naturalist.

Louis Jean Rudolf Agassiz, descendant from a long line of ministers, was born at the little village of Motier, Switzerland, between the lakes of Neuchâtel and Morat, May 28, 1807. In his early years he showed great fondness for the water and for the animals to be found in it, as well as for athletic sports; and when the time came for him to make the decision as to his life work, he turned aside from the ministry and from a business career and went to Zürich to study medicine. The school at Zürich at that time was nothing like that of to-day, for then the present university was not founded. So from Zürich he turned to Heidelberg, where he made acquaintances and friends, — the Schimpers and Brauns, who were to play no small part in his future development, some of these friendships persisting throughout his life. Here at Heidelberg he obtained

his first introduction into zoology and paleontology, fields which he was later to make peculiarly his own. For still greater facilities he and his friends soon turned to the newly established University of Munich, where in 1830 he received the degree of Doctor of Medicine.

During these undergraduate days he paid more attention to zoology than to the strictly medical studies, and his room became a great resort for others having similar tastes. Here each member had his special subject and delivered lectures upon it to the others, so that the term, "the little academy," applied to these meetings contained as much truth as jest. The life which Agassiz lived here has a lesson for our students. Making due allowance for the differences in prices, the money which his father and friends could give him for his education would fall far below that spent by our students to-day, and yet out of this pittance Agassiz not only supported himself and aided friends, but he employed an artist to draw the fishes for proposed works,—the fishes of central Europe and those collected by Martius and Spix in Brazil.

Here, too, he began his investigations upon the fossil fishes, and soon, by borrowing, he had at his command an enormous collection of these forms. The task was enough to appall most persons. The fossils were in all conditions of preservation, and in those days little was known of the osteology of the recent forms. Yet order was brought out of chaos, and these early studies were the foundation of all subsequent work in this line. It matters little if we can no longer use the scales as a character for the separation of the major groups of the fish-like forms; the *Researches on Fossil Fishes* shows great anatomical insight and powers of generalization.

These studies of fishes led him to Paris, then the great centre of all scientific work, and here he formed the acquaintance of Cuvier and Humboldt, and Cuvier opened the collections of fossil fishes in the museum to the young student. While in Paris he received the appointment as Professor of Natural Science at the Academy of Neuchâtel. When he began his labors there he was without facilities for his work; collections and apparatus, aside from his own private property, were lack-

ing; even rooms for his classes were with difficulty obtained. Yet he soon built up a most flourishing school of natural history. Out of his limited salary he supported collectors, assistants, artists, and secretaries. He went farther and became his own publisher and started a large lithographic establishment, the chief business of which was to furnish illustrations, in a style until then never seen, for the rapidly increasing series of works turned out from the busy hive.

The school at Neuchâtel was not a university, but Agassiz made it one of the scientific centres of the world. To it came visitors and students from all parts of Europe. That its prominence at this time was due solely to Agassiz is shown by the fact that when he left for the United States the academy at once sank back to its former inconspicuous condition, just as Upsala did when Linné died.

While here at Neuchâtel, pushing along the work on the fishes of central Europe, the fossil fishes, and the fossil echinoderms of the Jura, he became interested in the glaciers. To others we owe the discovery that glaciers move, and that in former times they covered more of Switzerland than they do to-day. At first Agassiz had little sympathy with such ideas, but as he studied the phenomena in the valley of the Rhone he was converted to the new views, and soon became the foremost authority in all that pertains to glaciers. Even were we to allow to Forbes and Schimper all that they claim, still it would be to Agassiz that we owe the systematization of the facts and the acceptance of the principles involved by the scientific world. As the work left Agassiz's hands it was about as complete as it could be without a knowledge of physical methods and phenomena such as Agassiz never claimed to have. Later Tyndall built upon Agassiz's foundation the glacial theory of to-day, rounding it out on the physical side and making it complete.

Each summer during these glacial studies was spent upon some of the glaciers of the Alps, where regular investigations of the most elaborate kind were carried on with the best of instruments, the Glacier of the Aar being the one the most thoroughly investigated. During the rest of the year Agassiz

worked at Neuchâtel, teaching his classes, directing his assistants, artists, etc., and working away at his various books, of which he had now in hand, besides those already mentioned, one upon fossil molluscs and one — the *Nomenclator Zoologicus* — the compilation of which must have been about as tedious a bit of work as one could easily imagine, but a work indispensable to the systematic zoologist of to-day. His work on fossil fishes had extended his reputation, and the treasures in the collections of several wealthy patrons of science in England were poured in to be worked over and incorporated in the series of volumes on these forms.

So from the scientific standpoint, affairs were most prosperous during these years at Neuchâtel, but financially they were far less rosy. Agassiz was not a business man, and his publications and his lithographic establishment were a terrible load. Books upon subjects of pure science never have paid their expenses, and the prospect is that they never will. So all the bills for artists, assistants, lithographers, and printers had to be paid from the small income of a professor in a provincial academy. At last the limit was reached and the lithographic establishment had to be sold.

At this time of financial distress Agassiz received, through the good services of Lyell, the geologist, an invitation to deliver a course of lectures before that unique institution, the Lowell Institute in Boston. Here was a chance to see the New World, and the opportunity was the more eagerly seized since the king of Prussia (Neuchâtel was then a part of the Prussian domain) gave Agassiz $3000 to aid him in his American explorations. Leave of absence was obtained from the academy at Neuchâtel and in 1846 Agassiz left for America, never to return to his Swiss home except as a visitor for a few months.

Boston received the newcomer with the greatest cordiality, and a little later Philadelphia and Charleston were scarcely behind in the warmth of their welcome. He hired a house in East Boston, and this soon became almost a repetition of the old home at Neuchâtel. Together with Agassiz, or following close upon his heels, came one after another of the old Swiss

friends and assistants, — Desor, Guyot, Marcou, Pourtalès, Girard, Richard, Sonrel, Burckhardt, and others, — so that it may be said that the work was merely transferred from the Old World to the New, the personnel of the establishment being much the same, but the work was changed in character.

In 1847 came the appointment to the Chair of Zoology and Geology in the newly established Lawrence Scientific School of Harvard College, and in the winter of 1848 Agassiz began his work as an instructor in the New World, — work which continued until his death, even the invitation to return to Paris as the head of the museum there being insufficient to call him back to Europe.

With this change from the Old World to the New, the work of Agassiz changed. It was not only that there was a change in the fauna: there was also a change in the man. In Europe his work had been largely systematic, although all of his papers had a strong substructure of anatomy. In America, surrounded as he was by a wealth of new and undescribed forms, one might have expected him to have become more purely a systematist than ever before. He became rather what to-day we would call a morphologist, and it is noticeable that in the majority of the papers he published in America, the structural or developmental side of the subject is the more prominent, the descriptions of new species occupying a subsidiary position.

Domiciled at Cambridge, Agassiz began collecting as never before. From all parts of the country specimens were obtained, but the only place for storage of them was a barn-like structure near the banks of the Charles. His trips to Charleston, where he early received an appointment in the medical school, enabled him to make collections in the semitropical waters there, while a trip to Lake Superior in 1848 resulted in large fresh-water collections. Besides, he arranged for exchanges of specimens with the museums of Europe and this country, and soon a larger building, a two-storied structure, long known as Zoological Hall, became the home of the specimens. This, however, was not safe from fire. It was built of wood, and, besides, a great part of the collections were preserved in alcohol, even more inflammable than the building itself. But where the

money to build according to his desires was to be obtained was for a long time a serious problem.

In 1858 Mr. Francis C. Gray left in the hands of trustees a bequest of $50,000 to establish a museum of comparative zoology. This fund was passed over into the control of Harvard College; friends raised by subscription over $70,000, while Agassiz labored with the Massachusetts legislature to such good effect that the Commonwealth appropriated $100,000 to properly house the collections. To the Museum of Comparative Zoology thus established — the Agassiz Museum as it is familiarly known in Cambridge to this time — Agassiz gave his private collections which had cost him in pecuniary outlay about $10,000.

The building then planned was to form three sides of a hollow square, the front to be 364 feet long and 64 feet wide, the two wings to be 205 feet long and as wide as the front. The part at first erected was but about two-fifths of one of the wings, and this portion, sufficient for all immediate needs, was formerly opened as a museum in November, 1860. To-day the whole of one wing is completed, about four-fifths of the front is occupied, while two-fifths of the other wing is built. There has been, however, a change in the plans in this respect. The museum is not purely zoological in character, but it contains as well the laboratories and collections of geology, mineralogy, and a large part of the botanical laboratories and collections (except the phanerogamic herbarium, kept at the Botanic Garden); while the Peabody Museum of American Archæology and Ethnology occupies the incomplete wing. Corresponding to this change, the whole structure is now known as the University Museums, the Museum of Comparative Zoology occupying the basement and five floors of one of the wings and a part of the front, with a total floor area of nearly three acres.

During his American life Agassiz made several extended scientific trips. In 1851 he went to Florida under the auspices of the United States Coast Survey; in 1865–66 he spent, with a party of friends, assistants, and pupils, ten months in Brazil, collecting chiefly in the valleys of the Amazon and Rio Negro, bringing back with him enormous collections to add to those

already at Cambridge. In 1871, again enjoying the hospitality of the Coast Survey, he sailed from Boston in the steamer "Hasler," passed through the Strait of Magellan, up along the west coast of South America and the Galapagos Archipelago, and finally reached San Francisco. This last trip was in many ways a disappointment, for the steamer itself was in poor condition and its equipment inadequate for deep sea dredging. Yet the collections made were very considerable.

But we must return to Agassiz's work at Cambridge, and especially to his work as a teacher. As time passed most of those who came with him from Europe either returned or obtained occupation elsewhere; but their places were taken by American students who were attracted to Cambridge by his name. It may be said that no teacher in recent years, unless it be the venerable Leuckart at Leipzig, has trained so many students who later arose to prominence in scientific lines as did Agassiz. The following names occur to us at the moment of writing — a little research would doubtless add to the number: J. G. Anthony, Alexander Agassiz, J. A. Allen, J. M. Barnard, Albert Bickmore, W. K. Brooks, Waldo I. Burnett, Caleb Cooke, Henry James Clarke, Thomas Clarke, William H. Dall, Walter Faxon, Jesse W. Fewkes, Samuel Garman, Charles Hamlin, Frederick C. Hartt, Alpheus Hyatt, William James, David S. Jordan, John L. Le Conte, Theodore Lyman, Horace Mann, James E. Mills, Charles S. Minot, Edward S. Morse, John Macready, William H. Niles, Albert S. Ordway, Alpheus S. Packard, John B. Perry, Frederick W. Putnam, Nathaniel S. Shaler, Samuel H. Scudder, William Stimpson, Sanborn Tenney, Philip R. Uhler, Addison E. Verrill, Burt G. Wilder, and Charles O. Whitman. When we look over the names of those who are doing the zoological work of America to-day, we find few who have not been trained by Agassiz, by his pupils, or by his pupils' pupils.

Agassiz's method of teaching was largely the laboratory method which we know to-day. Mr. Scudder has so well described his experience when he first went to study entomology with Agassiz that we cannot refrain from quoting from his account :

"When do you wish to begin?" he asked.

"Now," I replied.

This seemed to please him, and, with an energetic "very well," he reached from a shelf a huge jar of specimens in yellow alcohol.

"Take this fish," said he, "and look at it; we call it a Hæmulon. By and by I will ask you what you have seen."

With that he left me, but in a moment returned with explicit instructions as to the care of the object intrusted to me. "No man is fit to be a naturalist," said he, "who does not know how to take care of specimens." . . . Entomology was a cleaner science than ichthyology, but the example of the professor, who had unhesitatingly plunged to the bottom of the jar to produce the fish, was infectious; and though this alcohol had a very ancient and fish-like smell, I really dared not show any aversion within these sacred precincts, and treated the alcohol as though it were pure water. . . . In ten minutes I had seen all that could be seen in that fish. . . . Half an hour passed, an hour, another hour; the fish began to look loathsome. I turned it over and around; looked it in the face — ghastly! From behind, beneath, above, sideways, at a three-quarters view — just as ghastly! I was in despair. At an early hour I concluded that lunch was necessary; so, with infinite relief, the fish was carefully replaced in the jar, and for an hour I was free. . . .

Slowly I drew forth that hideous fish, and, with a feeling of desperation, again looked at it. I might not use a magnifying glass; instruments of all kinds were interdicted. My two hands, my two eyes, and the fish, — it seemed a most limited field. . . . At last a happy thought struck me, — I would draw the fish; and now, with surprise, I began to discover new features in the creature. Just then the professor returned.

"That is right," said he; "a pencil is one of the best eyes. I am glad to notice, too, that you keep your specimen wet and your bottle corked." With these encouraging words, he added: "Well, what is it like?"

He listened attentively to my brief rehearsal of the structure of parts whose names were still unknown to me. . . . When I had finished, he waited, as if expecting more, and then, with an air of disappointment, "You have not looked very carefully. Why," he continued most earnestly, "you have n't even seen one of the most conspicuous features of the animal, which is as plainly before your eyes as the fish itself. Look again! look again!" and he left me to my misery.

I was piqued; I was mortified. Still more of that wretched fish! But now I set myself to my task with a will, and discovered one new thing after another, until I saw how just the professor's criticism had been. The afternoon passed quickly, and when toward its close the professor inquired, "Do you see it yet?"

"No," I replied, "I am certain I do not; but I see how little I saw before."

"That is next best," said he earnestly; "but I won't hear you now. Put

away your fish and go home; perhaps you will be ready with a better answer in the morning. I will examine you before you look at the fish."

This was disconcerting. Not only must I think of my fish all night, studying, without the object before me, what this unknown but most visible feature might be, but also, without reviewing my new discoveries, I must give an exact account of them the next day. . . .

The cordial greeting from the professor the next morning was reassuring. Here was a man who seemed to be quite as anxious as I that I should see for myself what he saw.

"Do you, perhaps, mean," I asked, "that the fish has symmetrical sides with paired organs?"

His thoroughly pleased "Of course, of course!" repaid the wakeful hours of the previous night. After he had discoursed most happily and enthusiastically — as he always did — upon the importance of this point, I ventured to ask what I should do next.

"Oh, look at your fish!" he said, and left me again to my own devices. In a little more than an hour he returned, and heard my new catalogue.

"That is good, that is good," he repeated; "but that is not all; go on." And so for three long days he placed that fish before my eyes, forbidding me to look at anything else or to use any artificial aid. "Look! look! look!" was his repeated injunction.

This was the best entomological lesson I ever had, — a lesson whose influence has extended to the details of every subsequent study; a legacy that the professor has left to me, as he left it to many others, of inestimable value, which we could not buy, with which we cannot part.

Agassiz did a great work by his teaching, but he reached a wider circle by his popular lectures delivered before lyceums, teachers' associations, and farmers' institutes, as well as by his writings. Considering the time of its publication, no better text-book has ever appeared than the *Principles of Zoology* by Agassiz and Gould, first issued in 1848. Of this work, which bears the impress of Agassiz on every page, only the first part was ever published, but this part has passed through many editions and has a sale even to-day. The second part was prepared by Dr. Gould; the manuscript was written out, many of the engravings made, but Agassiz never found time to revise it as he wished. Other popular works which extended the influence of Agassiz far and wide were his *Methods of Study in Natural History*, first published in the *Atlantic Monthly*, and his two series of *Geological Sketches*, most of which first appeared in the same periodical.

In his more strictly scientific publications Agassiz employed the same sumptuous mechanical dress for his thoughts here as he did in Europe, and his *Contributions to the Natural History of the United States* is, even at this day, but rarely surpassed in beauty of presswork and quality of illustration. This work was to have been issued in ten quarto volumes, and the subscription list obtained (over 2500) before the first volume was issued is an index of the popular esteem in which the professor was held. Only four volumes were published and then the series stopped. Doubtless many of the subscribers expected gaily colored plates of birds and fishes and shells, such as were to be found in the then recently issued *Natural History of the State of New York*, and possibly some of them expected popular disquisitions on animals and plants something after the same style as was later furnished by the garrulous Rev. J. G. Wood. They received nothing of the sort. These four volumes were filled with an elaborate essay on the principles of zoological classification, a minute account of the development of the turtle, and details of the anatomy and histology of the Cœlenterata. The result was that the subscribers fell off. Agassiz, too, had so much other work to do that the series was never completed.

These same volumes, however, possessed great scientific value, and the *Essay on Classification* should be read by all, for nowhere will one find a clearer statement of the teleological argument, nowhere a better survey of the various systems of classification proposed at different times by the older masters. The work on the turtles is referred to elsewhere in this journal, but the studies upon the cœlenterates must not be ignored. This work marked a new departure in Agassiz's work. In Europe, removed as he was from the sea, he had no chance to study these forms, but at East Boston, at Charleston, and at his summer residence at Nahant this new world was opened up to him. So in the two volumes of the *Contributions* which deal with the cœlenterates we have a most valuable contribution to our knowledge of these forms. Here we find the demonstration that the millipores belong to the Hydrozoa rather than to the Scyphozoa. Here we find accounts of the life histories

of many of our hydroids; here details of the histology of these interesting forms. It is true that we can no longer agree with some of his theses. We no longer accept his views as to the homologies of the Radiata, nor can we longer adopt the Radiate group; but these changes, due to our increase of knowledge, detract but little from the general value of the work.

These volumes form the only extensive work published by Agassiz during his residence in America, but his shorter papers are both numerous and valuable.[1] He planned numerous other works, but none of these plans were carried out. The labor of teaching and the work demanded by a great and rapidly growing museum so completely occupied his time that there was no chance to carry out these contemplated investigations.

Three times was Agassiz recalled to Europe: in 1855 to the chair of zoology in the newly established University of Zurich, in 1857 to the head of the Jardin des Plantes in Paris, and in 1859 again to the same position. In spite of all of the attractions of these positions, he decided to remain in America, and at the beginning of our Civil War he showed his faith in the United States by becoming a naturalized citizen,—an American by right as well as by residence.

During the latter years of his life his originally strong constitution began to show the effects of early exposure and of overwork. Several times he had to give up entirely and to rest, but any long rest was impossible for him. In 1873 came the chance to establish a summer school for teachers, and the labors connected with the short-lived but ever-memorable school at Penikese told severely upon him. Still he kept at work, and even as late as the 2d of December he delivered a lecture before a farmers' institute at Fitchburg, his last public appearance. December 6 he was taken with paralysis of the larynx, and on Dec. 14, 1873, death came. Agassiz is buried at Mt. Auburn, and his monument is an Alpine boulder from the Glacier of the Aar, while around it grow pines transplanted from the hill behind Neuchâtel.

[1] A practically complete bibliography is given in Marcou's *Life of Agassiz*. It enumerates 425 titles.

THE PHILOSOPHICAL VIEWS OF AGASSIZ.

ALPHEUS S. PACKARD.

THE school of biological thinkers and writers to which Louis Agassiz belonged was that of Cuvier and of Owen. He was, however, the pupil of Döllinger, who revolutionized the methods of teaching in zoology, and he warmly sympathized with and adopted the views and principles of Von Baer, the great embryologist.

The half-century which has passed since Agassiz came to America has seen a profound and widespread modification of the methods of attacking biological problems. The facts may be of the same general nature, but their interpretation has radically changed; and it is fair to say that the labors of Agassiz in embryology and paleontology had some influence in leading to this change.

The impression made by Agassiz on the writer's mind, when a student for three years in the great museum he founded, was one of admiration at his broad, comprehensive, and synthetic views, his facility in wide generalization, his knowledge of the work done by his contemporaries and predecessors in comparative anatomy, embryology, and systematic zoology, and his acquaintance with the literature of these subjects. We realized that he was constantly in touch with the leading investigators in Europe. We were sure we were enjoying the privilege of working under the direction of a ripe zoological scholar and of the best equipped teacher of his age. It did not seem necessary to go to Germany, for we were enjoying advantages equal to those of the best German laboratories.

To-day we find more practical teachers than Agassiz, in that the student receives more of the teacher's time, is carried on from one step to another, is taught the use of the microtome and of reagents, and in most cases — for there are brilliant exceptions — half or two-thirds of the results as embodied in the doctor's thesis represent the work of the teacher who has

suggested the subject and laid out the plan of study, with a minor portion really contributed by the student himself.

Agassiz may have left his students too much to themselves, but he had what most teachers do not possess, — the power of leading his students to take broad views of a subject. As a teacher, then, Agassiz was broad and philosophical, and his pupils were constantly urged to add to their special work on the anatomy or embryology of some animal a wider knowledge of the relations of the animal itself to its allies and to the world it lived in, and more particularly to its fossil allies.

Philosophy inquires into the causes and meaning of things, philosophy thinks and speculates, and philosophy is nothing unless comparative in its methods. Agassiz was in season and out of season urging us to think at every stage of our investigation, to inquire what is the meaning of this or that feature or change in organs during growth, and at every step we were told to compare. His earliest lectures, delivered to popular audiences, soon after his arrival in this country were on "Comparative Embryology." The great museum he founded was the Museum of Comparative Zoology. Whatever he wrote or whenever he spoke his ideas were large, synthetic, and philosophical. It was these magnificent qualities, together with his undying enthusiasm, which made Agassiz one of the greatest of teachers in that line of great teachers of modern biology whose intellectual parents were Döllinger and Von Baer.

From Agassiz as a philosophical teacher let us turn to his work as an investigator, and inquire whether philosophic, synthetic methods were here employed by him.

Undoubtedly Agassiz's most important, far-reaching, and permanent contribution to science was the glacial theory. At the outset prejudiced against the idea of Venetz and of Charpentier as to the former great extent of the Swiss glaciers, after personal conversation and discussion with the latter geologist he became convinced of his error. He spent several summers among the Swiss glaciers, afterwards visited Great Britain, observed moraines, studied rocks and boulders, and inferred that glaciers had formerly existed in Wales and Scotland, that northern Europe had once been

mantled in ice, and that there had been a great ice age in that part of the earth. If he was a philosopher, he was not less a man of the world, a skillful and ready debater, a hard hitter in controversy, a persuasive and silver-tongued orator; and thus equipped, he overcame the prejudices of the geologists of that day, who were then wedded to diluvial currents, debacles, as well as impossible subsidences; and before his advent to these shores, he had convinced the scientific world that the greater part of the eastern hemisphere had been ice clad. Always observing and comparing, when he landed at Halifax and journeyed to Boston, afterwards geologizing in the White, Green, and Adirondack Mountains and about Lake Superior, he firmly established the truth of a general glacial period. And it is rather interesting to note that while the universality of the Darwinian theory of the formation of atolls by subsidence is now very generally called in question, and the adequacy of the theory of natural selection as a *vera causa*, or at least a primary factor, in evolution is denied by such a philosopher as Herbert Spencer, and by many evolutionists, the glacial theory is universally held, its opponents being so few that we can count them on the fingers of one hand.

When, however, we consider Agassiz as a zoologist or a biologist, and remember the determined way in which he opposed the doctrine of evolution in pre-Darwinian days, attacking on every occasion Lamarckism and the views of the *Vestiges of Creation*, and after the publication of the *Origin of Species*, letting no opportunity be lost in combating its supposed heretical views, we might be led to say, as has been said, that, after all, Agassiz was no philosopher; that he was slightly fanatical and somewhat bigoted and set in his views and illogical in his methods. It is true that in his prime and after a lifelong work in teaching the facts and principles which underlie and form the foundation on which the doctrine of evolution rests, he illogically stopped short of obvious and natural conclusions, and, unlike Lyell, Dana, and others, failed to adopt the new views.

The causes of his failure to come into line with the new zoology were in part, perhaps, the result of theological preju-

dice, of scientific conservatism, and other subtle reasons, and in part the result of his trained scientific mind accustomed to think more or less in one channel, not allowing itself to speculate too freely on too few facts. On the whole, however, the theory of descent was contrary to his whole nature and training; we can in this regard only liken the career of this great naturalist to one of his own "closed types." There are zoologists who attempt the impossible; who would refer, for example, the origin of vertebrates to Crustacea or to Limulus, overlooking the fact that these classes are the final terms in lines of development and are fully completed. So the special creation idea was unproductive, and a Darwin was needed to open men's eyes to new conceptions, to illumine well-known facts from a fresh point of view.

But it should never be forgotten that Agassiz from the beginning of his career advocated certain doctrines which underlie the theory of descent. The first of these is the foundation of the biogenetic law. He insisted that the development of the individual is an epitome of that of the order or class to which it belonged, though unfortunately he stopped short of the logical outcome of such a generalization; *i.e.*, that there is an organic or genetic connection between the forms composing the class.

The second principle is the parallelism between the geological succession of animals and their respective rank in the present period. He points out repeatedly that the lower types preceded the higher. For example, in the Crustacea the gradation of forms presents the most perfect coincidence with the order of succession of these animals in past geological ages. His "lowest" forms are the generalized types of zoologists of the present day, and his "higher" types the more specialized.

All this prepared the minds of his students to accept the truth of a process of evolution of life-forms from the generalized to the specialized types. His "embryonic," "synthetic," and "prophetic" types are in many cases the ancestral types of the modern evolutionist. His embryonic types "represent in their whole organization early stages of the growth of higher representatives of the same type." He maintained that "the

phases of development of all living animals correspond to the order of succession of their extinct representatives in past geological times. As far as this goes, the oldest representatives of every class may then be considered as embryonic types of their respective orders or families among the living."

Agassiz's prophetic types are those which "combine in their structure peculiarities which at later periods are only observed separately in different distinct types." As examples he mentions the ganoids, fishes, pterodactyles, and the ichthyosaurs. He, however, regarded ganoids as more distinctively synthetic than prophetic types. Now we refer the origin of bony fishes, of Amphibia, and of reptiles to the ganoids. Agassiz fully appreciated the more salient facts on which this generalization rests, and we may think it strange that it did not occur to him that the connection could only be explained by supposing that it was a genetic one.

In this respect Agassiz did not rise above the limitations of his time and of his own nature, but the facts he worked out, or which his students and collaborators discovered, were freely given to his students; and in this respect if he did not grasp, or was unwilling to accept, the conclusions of Lamarck and of Darwin, he paved the way for the adoption by his students of evolutional views.

How well does the writer remember a conversation he once held with Agassiz at Penikese, in the summer of 1873. We had given a lecture to our class on Limulus, the horseshoe crab, its structure and mode of development, at the close advocating without reserve the view that Limulus does not stand alone, but that it is genetically related to other jointed animals, and that there are different lines of development of life-forms. At the close of the hour, and after the class had scattered to the work tables, Agassiz, who had been present, strode up and down the room in a state of evident, though repressed, excitement, and then remarked to us with one of his most genial smiles on his lips: "I should have been a great fellow for evolution if it had not been for the breaks in the paleontological record." We replied: "But, Professor, see what great gaps in the higher vertebrates have been filled by the recent discoveries of birds

with teeth, and of Tertiary mammals connecting widely separated existing orders." And then, with a few more words, which we do not distinctly remember, we separated. Not a sign of displeasure during that August afternoon disturbed the genial and sweet nature of the great naturalist. He was not then, though occasionally so, dogmatic. The touch of bigotry, if we may use so strong a word, which existed in his, as it does in many an intense, eager, clear-minded spirit, did not then crop out, and it was one of the most delightful moments we ever spent with that eminently lovable man. Agassiz had then just passed his sixty-sixth year; and, after having for years combated the principle of evolution raised by Lamarck and by the author of the *Vestiges of Creation*, he did not, unlike his contemporaries Lyell, Wyman, W. B. Rogers, and others, change his views.

And so it is, in youth the older naturalists of the present generation were taught the doctrine of creation by sudden, cataclysmic, mechanical, "creative" acts; and those to whose lot it fell to come in contact with the ultimate facts and principles of the new biology had to unlearn this view, and gradually to work out a larger, more profound, wider-reaching, and more philosophic conception of creation.

AGASSIZ AND THE ICE AGE.

G. FREDERICK WRIGHT.

AGASSIZ did not claim to be the first one to see that the glaciers of the Alps formerly filled the valley of the Rhone in Switzerland and extended to the summits of the Jura Mountains. The credit of this brilliant theory he freely gave to his hospitable friend Jean de Charpentier, Director of Mines in the Canton of Vaud and living at Bex, a few miles above the head of Lake Geneva. Nor was the theory original with Charpentier. A mountaineer named Perraudin, living at the foot of the St. Bernard in Vallais, told Charpentier as early as 1815 that the large boulders along the sides of the Alpine valleys were left there by glaciers which once filled them. Fourteen years later, in 1829, an engineer named M. Venetz recalled to Charpentier the theory of Perraudin and advocated its truth. This belief of the Swiss engineer was defended in an essay read to the Swiss naturalists in 1821, but the paper remained unnoticed until Charpentier became a convert to the theory through the arguments of Venetz in 1829. The paper was not published, however, until 1833, the same year in which Charpentier's first paper on the subject was published.

But, although this paper of Charpentier presented the facts from the hands of a master, it did not convince Agassiz or many others. In 1836 Agassiz and his wife, however, accepted an invitation to spend their summer vacation with Charpentier at Bex, with the result that he returned to his home at Neuchâtel an enthusiastic advocate of the glacial theory. And well he might be, for he had himself been living among the most remarkable indications of glacial work that could anywhere be found in the world. The very soil beneath his feet was composed of the Alpine glacial grist. The whole valley was gridironed with moraines, while one of the largest known Alpine boulders, the *pierre à bot*, rested high up on the flank of the Jura Mountains, not far from Neuchâtel.

But, carefully as Charpentier had worked out his limited theory for the valley of the Rhone, he was not prepared for the far grander and more brilliant generalization which Agassiz was ready to propose. In an epoch-making address delivered at a gathering of naturalists at Neuchâtel on July 27, 1837, Agassiz propounded the theory that within a geologically recent period the whole northern hemisphere, as far down as the Mediterranean and Caspian Seas, had been covered with a vast sheet of moving glacial ice, maintaining that the glacial drift around Neuchâtel did not come from the Alps, but from the north.

Brilliant as was Agassiz's presentation of this theory, it astonished rather than convinced his hearers. Among these were Von Buch and Elie de Beaumont, two of the most influential geologists of the time, both of whom were fairly horrified by the seeming extravagance of the theory. Agassiz was then but thirty years old, and had strong hopes of being promoted to a professorship in some of the larger universities of Europe. The indorsement he had received from Cuvier and Humboldt amply justified him in such expectations. But whatever the prospects had been before, they were scattered to the winds by this address with its unfavorable effect on the minds of the influential naturalists who were present.

Even the warmest admirers of Agassiz would not contend that all portions of his theory as first presented were correct. He was mistaken in supposing that the ice which covered Switzerland had any of it come from the north. Charpentier was right in holding that the Alps constituted the centre of the whole glacial movement in that part of Europe. But Agassiz was correct in his belief that there had been a general refrigeration of the northern hemisphere which had profoundly changed both the plants and the animals of the whole region. The theory as propounded by Agassiz and afterwards verified by him is scarcely less grand, impressive, and revolutionary than was that of the Copernican system of astronomy, while the work of verifying, defending, and giving currency to the theory demanded scarcely less genius than that of its origination. But for this task also he was fully competent.

In 1838 he began that careful study of the Alpine glaciers which brought out most of the facts which have since convinced the world of the reality of the glacial period. With a party of six he ascended the valley of the Aar to the Grimsel Pass, and, upon his return after ten days, started at once for Chamounix, where the party was gone a week. With the additional facts gathered in these trips, Agassiz attended the meeting of the Geological Society of France at Porrentrui (Sept. 5, 1838), where he was more successful than the year before in convincing the sceptical of the truth of his theory. In August, 1839, Agassiz resumed his glacial studies, and, taking with him a number of eminent geologists, visited Monte Rosa and the Matterhorn, when, after studying the Gorner Glacier, he made a visit to the Aletsch Glacier and the Merjelen Lake, and thence went on to the Glacier of the Rhone, subsequently visiting again the Grimsel Pass and the Glacier of the Aar. As a result of this excursion, the most determined opponents of the glacial theory who accompanied him became convinced.

The characteristic respect which Agassiz paid to ordinary observers appears in a conversation of his with his guide to the Gorner Glacier. "Seeing a vertical wall of serpentine finely polished, he asked the guide to what that phenomenon was due. The guide, who had not the smallest interest in the glacial question, answered with great *naïveté* that in the country (*le pays*) everybody thought that it was made by the glacier, adding: 'It is true that no inhabitant of the village remembers to have seen the glacier in this place, but it was there formerly, for it is always in this way that the glaciers wear away the rocks.'"[1]

Upon this excursion Agassiz was taken by his guide to see the cabin upon the Glacier of the Aar which had been built and occupied by the monk Hugi of Soleure in 1827. Ten years later it was found that the cabin had moved downward with the surface of the glacier a distance of 2028 feet, or about 200 feet per annum. Agassiz resolved to return the next year and either reoccupy this cabin or build one for himself.

[1] *Life, Letters and Works of Louis Agassiz*, by Jules Marcou. New York, Macmillan, 1896. Vol. i, p. 145.

Meanwhile his observations had been already so complete that he felt himself justified in writing an extended work setting forth his glacial theories. This volume, entitled *Études sur les Glaciers*, was published in September, 1840, and was accompanied with eighteen beautiful plates. In the treatise explicit reference is made to the prior discoveries of Venetz and Charpentier, the work, indeed, being dedicated to them. Nevertheless, considerable ill feeling arose on account of this priority of publication.

In August, 1840, Agassiz returned to Hugi's cabin on the Glacier of the Aar with the intention of occupying it, but found that it had disappeared, there being only some of the *débris* remaining two hundred feet below the position occupied by it the year before. Whereupon Agassiz proceeded to build for himself a shelter under the projecting side of a huge boulder which was a prominent object upon a medial moraine. With this as the centre, he, with numerous colaborers, carried on for three successive summers those minute and careful observations upon glaciers which have been the basis of all subsequent speculation. In order to study the interior construction, they made deep borings into the ice, and on one occasion Agassiz was let down by a rope one hundred and twenty feet into a crevasse, while on another he spent a lonely night on the Siedehlhorn. To determine the rate of motion, he set a row of stakes across the glacier and took observations to determine their changes of position during an extended period.

While this work was in progress, Agassiz was visited by James D. Forbes, an English engineer of eminence, who spent some weeks with the party on the Aar Glacier in 1841. A year later Forbes returned to Switzerland and with his accurate mathematical instruments made observations upon the Mer de Glace sufficient to determine accurately the laws of its motion. A report of this was published by Forbes in the Edinburgh *New Philosophical Journal* in its issue for October, 1842. The report was dated, however, July 4, 1842. Meanwhile Agassiz had published the results of his observations upon the movements of the Aar Glacier in the *Comptes Rendus* of the 29th of August, 1842, two months before the publica-

tion of Forbes's letter. But Agassiz's report was dated twenty-seven days later than that of Forbes. Naturally enough, this complicated condition of things led to a spirited discussion as to priority of discovery. But there can be no question of Agassiz's originality in the matter. Without any reference to Forbes, he had, by his slow process of observing his stakes during a succession of years, determined that the central portion of the glacier moved faster than the portion near the side; for in 1842 the stakes in the middle of the glacier, set the year before, were one hundred feet farther down than those near the sides. On the other hand, Forbes has never been able to free himself from the suspicion of having unfairly availed himself of Agassiz's generous hospitality to copy his method and put it into execution at the earliest opportunity.

Having thus convinced the Swiss geologists that their own country had once been completely enveloped in glacial ice, the still more difficult task remained of extending the theory to other countries. The first opportunity for such extended observation offered itself during the autumn of 1840, when Agassiz attended the meeting of the British Association at Glasgow, when, during numerous excursions taken over the north of England, Scotland, and Ireland in company with Buckland and Lyell, he established the fact that all those regions had been deeply enveloped in glacial ice. Murchison, however, with many other eminent British geologists, continued to doubt the theory and to endeavor to explain the scratches on the rocks, the transportation of boulders, and the accumulation of moraines on the iceberg theory. During this visit Agassiz's quick eye saw the resemblance between the parallel roads of Glen Roy and such terraces as would naturally form around a glacial lake such as he had studied in the Merjelen Sea, on the border of the Aletsch Glacier.

Agassiz's last visit to the Glacier of the Aar was at the beginning of 1845, when he transferred his observations to Daniel Dollfus-Ausset, who faithfully continued them until 1861.

Agassiz, meanwhile, was approaching the great crisis of his life. Business failures broke up his work at Neuchâtel, and

he came to America in 1846 to give a course of Lowell Institute Lectures in Boston, which he had been invited to do upon the recommendation of Sir Charles Lyell. With imperfect knowledge of English he succeeded in holding immense audiences on the general subject of "The Plan of the Creation, especially in the Animal Kingdom." The course was a marked success, notwithstanding his unfamiliarity with the English language. But it was followed by one more to his liking, given in the French language, upon "Les Glaciers et l'Epoque Glaciaire." From this time on the incidental observations of the great naturalist upon glacial phenomena became a most important part both of his own work and of the general literature of the subject.

In 1848 Agassiz made his celebrated excursion to Lake Superior in company with a small party of Harvard College students and Boston gentlemen. In a remarkable volume, now difficult to obtain, which resulted from this expedition, there is to be found a great wealth of glacial observations made at every stage of the journey. It was indeed a grand verification of his original theory. In 1864 Agassiz made an extended excursion in Maine, and brought back an immense amount of material in support of his glacial theory. The *Atlantic Monthly*, in an article entitled "Glacial Phenomena of Maine," contains his report upon the moraines and eskers and kames which there so reminded him of similar phenomena in his native country. The abundant later literature upon the subject is little more than a commentary upon these original observations of the great promulgator of the glacial theory.

In 1865 and 1866 Agassiz made extended explorations in Brazil mainly in the interests of biological science. In a side trip, however, which he made amid great difficulties in the rainy season in the Province of Ceara, 4° south of the equator, he thought he discovered numerous medial, lateral, and frontal moraines at an elevation of only eight hundred feet above the sea. But it is supposed by later observers that he was misled by the resemblance to glacial phenomena which often arises in connection with the slow disintegration of granitic masses in which the residuary boulders sometimes have a close resem-

blance to those which are distributed by glacial transportation. But in a later tour, in 1871 and 1872, around South America and through the Strait of Magellan, his glacial observations were very extended and of the highest value.

Thus, when the end came, Agassiz had lived, not only to see his brilliant theory generally accepted in its main features, but himself to verify it in both hemispheres and in three of the great continental masses. When we remember that glacial studies were merely his avocation, occupying but the spare hours of one whose life was overcrowded with other work, our admiration both for the genius and the industry of this great man can find no adequate expression. His incidental work was really greater than that which is accomplished by the main efforts of most men. It is fitting that a glacial boulder from his native land should mark his burial-place in the cemetery at Mt. Auburn, where his body lies amid the glacial accumulations which he himself had made so luminous and so instructive.

OBERLIN, December 18, 1897.

AGASSIZ ON RECENT FISHES.

DAVID STARR JORDAN.

About 1827, when Louis Agassiz was some twenty years of age, a student in the University of Munich, Spix and Martius returned from their travels in Brazil, bringing with them a large collection of fishes.

Agassiz was then a favored student of Dr. Döllinger, resident in his house, where in his modest apartments he maintained his "little academy," "sleeping-room, fencing-room, museum, and laboratory all in one," and here he kept the collection of fish skeletons which the anatomist Meckel once came all the way to Munich to see. He had already studied the structure and breeding habits of the fishes of Lake Neuchâtel, and his reputation was established as a man that knows fishes.

The collection of Spix and Martius was placed in Agassiz's hands, to be treated according to the best methods of systematic zoology. This the young man did to the best of his ability, taking the classic writings of Bloch and Lacépède as his model, and doing with his material quite as well as these fathers of ichthyology could have done.

The *Piscium Brasiliensium*, published in 1829, made a large, thick quarto, on heavy paper, with detailed descriptions and colored full-page illustrations of each species. The engravings were poor and costly, after the fashion of the time, and the descriptions elaborate, but uncritical, being formed after bad models before good models existed.

Criticism and comparison in zoology was first introduced by Cuvier, and most of Cuvier's descriptive work was in 1827 still in the future, though numerous references in the text to letters from Cuvier show that Agassiz had tried to make the best use he could of the help of his master.

A number of papers on the fresh-water fishes of Switzerland and neighboring regions were published in following years, —

worthy fruits of Agassiz's professorship in Neuchâtel. Those on the Salmonidæ treated largely of problems of development, at once most difficult and most interesting. Others took up the classification of the complicated family of Cyprinidæ (carp, chubs, dace, and minnows), with an attempt to divide the group into genera founded on natural — that is, anatomical — characters.

Similar attempts were made at about the same time by John J. Heckel and by Charles Lucien Bonaparte with much the same results. On the whole, Agassiz's work was the more successful as well as earlier in time.

For a number of years the fossil fishes and the glaciers occupied most of Agassiz's scientific activity.

In 1846 he came to America, accepting a chair in Harvard College, and was soon engaged in exploring the natural products of the New World, to which he "came in the spirit of adventure and curiosity," and in which he stayed "because he liked the land where he could think and act as he pleased; the land where nature was rich, while tools and workmen were few, and traditions none."

In America he soon renewed his interest in the fishes. In 1850 he published his volume on Lake Superior, which contained among other things an account of the fishes collected by himself and his students in a summer's trip of exploration.

In this volume, which is accompanied by excellent stone engravings, we see more of Agassiz's tendency to philosophic discussion. A remarkable new species, Percopsis, the type of a new family of ancient lineage, suggests to him many thoughts as to the succession of forms among fishes, though he was still unprepared to see in this a genetic relation. The descriptions of species in this book are very detailed, but not at all critical. They seem like the work of students, as they doubtless were, for whoever was in Agassiz's company was always set to work along the line of his thoughts. Agassiz's own best work was not in the line of description, but rather in suggestion. He had a keen eye for generalization, as for comparison and classification. His later papers on fishes were of the nature of syllabi and suggestions rather than of finished work, but they

play a very large part in the history of the systematic zoology of North America.

One of the most important of these was a critical study of the fauna of the Tennessee River, published in 1854, and based chiefly on collections made by Mr. Newman at Huntsville, Ala. In this paper he discussed certain problems of the distribution of fresh waters and indicated new ones. If he had answered these by inductive observation, he would have been led, as his students have been, at once into the belief in the transmutation of species.

In 1855 a collection of fishes from the western parts of the United States led him to a consideration in detail of the proper classification of our fresh-water fishes. Most of the many genera here proposed by him have stood the test of time, but in a few cases the true relation of forms was not fully understood. At about the same time, Dr. A. C. Jackson, of San Diego, called the attention of Professor Agassiz to the group of viviparous surf fishes (Embiotocidæ) which constitutes the most remarkable feature of the fish fauna of California. Agassiz took up the study of this group, described many of its genera and species, and gave an interesting account of its remarkable anatomical features. At almost the same time the same peculiarities were independently studied by Dr. W. O. Gibbons, of Alameda, and by Dr. Charles Girard, of the Smithsonian Institution, himself one of Agassiz's students. Agassiz's papers have priority of date, and the generic names given by him, especially the type name of Embiotoca, this word an inspiration in itself, are in general the ones to be retained.

After 1855 no papers of importance relating to fishes were published under Agassiz's own name. We find the influence of his views and example in the work of his students, notably Girard, Putnam, and Garman, as well as in that of Baird, Storer, and others who were indebted to him in one way or another for assistance.

Concerning the vast wealth of his Brazilian and other South American collections, Agassiz has written little. The basement of the museum at Cambridge is still crowded with unstudied material collected by Agassiz. Much of this material has been

investigated by Steindachner, Garman, Eigenmann, and the present writer, but with all that has been done there remains a residue rich in undescribed species.

Although the study of recent fishes was only a minor incident in Agassiz's multifarious activities, it was a branch in which he felt the deepest interest. His keen and broad insight helped him to bring its chaos into order, and his name deserves a large place in the history of systematic ichthyology.

With all his acumen, Agassiz was never able to correctly interpret the facts of the succession of the fishes. He said to me in 1873: "At one time (about 1842) I was on the verge of anticipating Darwinism, but I made up my mind at last that progress by transmutation of species could not be, because we had our highest fishes first."

Of course this is true in a sense, because the ganoid fishes are beyond a doubt nearer to the higher vertebrates than the recent fishes are, and the early sharks are in some regards (brain, reproductive system, alimentary canal, and teeth) more highly developed than is the case with the true or modern fishes. But neither of these facts, as we now understand, bears on the real question. The ganoid fishes constitute a synthetic or generalized type, from which at least two great lines of descent have sprung. From the double-breathing or amphibious ganoids we have descended the Batrachia, who pass through the fish-like or water-breathing stage as a phase of youth. From these come the Reptilia, who pass through their fish-like stage in embryo. And from Reptilia come the warm-blooded mammals and birds. The other great line of descent remains aquatic and fish-like. Its line of specialization has been to make its members more and more intensely *fish*. The purely aquatic life demands not higher development, but adaptive or "fish-like" structure. The typical recent fish loses its amphibian possibilities very early in life, and its development is along the lines of the demands its fish life is to make. In the abstract a modern fish is not "higher" than its ancient ganoid ancestors; nor is it properly in most respects lower. It has diverged and is become specialized and adapted to its condition in life. Adaptation, not progress, is the meaning of organic evolution.

AGASSIZ'S WORK ON FOSSIL FISHES.

CHARLES R. EASTMAN.

WHATEVER advances have been made in the science of paleichthyology since the time of Louis Agassiz, it is a significant fact that they have been rendered possible almost solely as the result of Agassiz's own researches. The position that Agassiz holds in the history of the science is that of founder, of extraordinarily acute and painstaking observer, of careful and sagacious systematist. If he was the first to place the study of paleichthyology upon a truly scientific basis, so, too, his contributions to this subject greatly preponderate over those of any other author. And not only was the knowledge of fossil fishes vastly increased by means of his writings, but, both directly and indirectly, he stimulated other investigators to pursue kindred lines of research.

It was especially fortunate that Agassiz should have been led to take up the study of fossil fishes when he did, for the reason that he possessed a more extensive knowledge of recent forms than probably any other savant in Europe with the exception of Cuvier, who unhappily did not live to see even the inception of the *Poissons Fossiles;* and also because there existed in the different museums at that time a large array of material, eminently suited for comparative investigation, and waiting only for a monographer. Without the wide experience in zoology and anatomy that Agassiz had already enjoyed, without his powers of penetration, of fine discrimination, and excellent judgment, it is safe to say that no one could have prepared a well-digested account of so much new material, nor have made clear the structure and relationships of such fragmentary remains. Genius, without training, could not have accomplished the masterwork which Agassiz performed, but the value of a trained scientific imagination was most forcibly illustrated in his case.

The circumstances which led Agassiz to enter upon the study of paleichthyology were largely fortuitous. When a student at Heidelberg, being then scarcely twenty years of age, he attended a course of lectures on paleontology by Professor Bronn, a teacher of profound erudition, and for whom he always entertained feelings of the warmest regard. The first portions of Goldfuss's great work, *Petrefacta Germaniae*, were then just issuing from the press, and awakened a sensational interest in geology and paleontology. The highly fossiliferous rocks of southern Germany were eagerly searched by collectors, and large gatherings found their way into the principal museums. Munich in particular became the repository of those exquisitely preserved remains which have made the name of Solenhofen famous in the annals of paleontology for all time. And thither, to Munich, Agassiz came before he was twenty-one, yet not without having made the acquaintance of almost every large-sized collection in the land. To use his own words, as given in a brief account of his university life, "I knew every animal, living and fossil, in the Museums of Munich, Stuttgart, Tübingen, Erlangen, Würzburg, Carlsruhe, Heidelberg, and Frankfort."[1]

The project of preparing a general work on fossil ichthyology seems to have first taken shape in his mind while a student at Heidelberg; its feasibility was impressed upon him after an examination of the above-mentioned collections, and on receiving numerous friendly offers for the loan of specimens; and its initiation dates from the period of his removal to Munich, if we may judge from a letter written to his brother in January, 1830, from which we quote as follows:

> Having by permission of the Director of the Museum one of the finest collections of fossils in Germany at my disposition, and being also allowed to take the specimens home as I need them, I have undertaken to publish the ichthyological part of the collection. Nowhere so well as here, where the Academy of Fine Arts brings together so many draughtsmen, could I have the same facility for completing a similar work; and as it is an entirely

[1] *Louis Agassiz, His Life and Correspondence*, by E. C. Agassiz. Boston, 1885. Vol. i, p. 157. On the growth of some of these institutions and the influence of Bronn and others, see an article by K. A. von Zittel, in *American Geologist*, vol. xiv, 1894, pp. 179–185.

new branch, in which no one has as yet done anything of importance, I feel sure of success; the more so because Cuvier, who alone could do it (for the simple reason that every one else has until now neglected the fishes), is not engaged upon it. . . . Now that I have it in my power to carry out the project, I should be a fool to let a chance escape me which certainly will not present itself a second time so favorably.

Three years after the date of this letter the first *livraison* of his immortal *Poissons Fossiles* appeared, the publication of which in five large quarto volumes, illustrated by nearly four hundred folio plates, extended over the interval from 1833 to 1844, and was followed by a supplementary volume, entitled *Monographie des Poissons Fossiles du Vieux Grès Rouge oú Système Devonien* (*Old Red Sandstone*), with an atlas of thirty-three plates, in 1844–45.[1]

The author's work on this "vaste publication" was embarrassed by difficulties of the most aggravating nature. There were first of all the exacting terms imposed by his publisher, Cotta of Stuttgart, who eventually withdrew from the undertaking as being too expensive; and afterwards the financial hazard involved in the maintenance of a private printing establishment. The restrictions of many museum authorities relative to the transportation of specimens proved also a serious hindrance, necessitating as it did a journeying about on the part of himself and an artist until he had ransacked every collection worthy of the name in Europe. To say nothing of the personal expense and labor he was subjected to by this plan, it was unsatisfactory for yet another reason, to which he refers as follows in the preface to his *Poissons Fossiles:*

Notwithstanding the cordiality with which even the most precious specimens have been placed at my disposition, a serious inconvenience has resulted from this mode of working; namely, that I have rarely been able to compare directly the various specimens of the same species from different collections, and that I have often been obliged to make my identification from memory, or from simple notes, or, in the more fortunate cases, from my drawings alone. It is impossible to imagine the fatigue, the exhaustion of all the faculties, involved in such a method. The hurry of traveling, joined to the

[1] For the actual dates of publication of the various parts and plates, see the list compiled by W. H. Brown, and prefixed to the *Catalogue of British Fossil Vertebrata*, by A. S. Woodward and C. D. Sherborn (London, 1890), pp. xxv–xxix.

lack of the most ordinary facilities for observation, has not rendered my task more easy.

The incidents that befell him while prosecuting his researches; the friendships he formed with all the distinguished scientists of the day; the favorable impression he everywhere created, especially in Britain, where his fame had preceded him; the influence of Humboldt and Cuvier upon his career; his prodigious energy, enthusiasm, and devotion to his chosen purpose; the personal qualities drawn out by the struggles and hardships he endured; his gratification at the final acknowledgment of his success, — all these are topics which have been abundantly treated of by his biographers. It remains for us merely to call attention to some of the more general features of his work on paleichthyology. But here, too, it will be difficult at this day for one to offer anything novel, since during the last half-century it has been frequently and ably reviewed.

We can only add our tribute, in a word, that the publication of the *Poissons Fossiles* laid the foundation of a new science, and reared at the same time a large portion of its superstructure. This work also marked an epoch in the history of paleontology and zoology in general, since one of its brilliant results was the discovery of certain comprehensive laws, which are now admitted to be of fundamental importance. Without doubt the most far-reaching of these in its consequences is the analogy which he pointed out between the embryological phases of recent fishes and the geological succession of the class; whereupon he deduced the generalization, "The history of the individual is but the epitomized history of the race." Another notable result was the recognition and characterization of his so-called prophetic or synthetic types, that is, such as embrace features in their organization which afterwards become distributed among a number of groups, and are never recombined. Incidentally, or rather as a corollary to the preceding, he introduced a new method of studying animal types; namely, that of testing zoological results by embryological investigations, and, similarly, embryological by paleontological. He insisted that the comparative anatomy of a group, including its paleontological record, should be studied in connection with the comparative

embryology of the same; in fine, as he says, "The results of these two methods of inquiry complete and control each other."

In this memoir Agassiz also worked out the geological succession and distribution of the different groups of fishes, thereby greatly increasing the practical value of their remains as an aid in identifying strata. His observations upon the heterocercal tail, its duration in time, and, owing to accelerated development, its transitory appearance in the early stages of recent forms deserve notice in this connection. The principles of tachygenesis seem to have been fully grasped by him, although not distinctly formulated. To him properly belongs the credit, also, according to the testimony of one of his students at a later date,[1] of having first apprehended and expounded what is commonly called the biogenetic law of Haeckel.

Yet another important feature of the *Poissons Fossiles* was the proposal of an entirely new system of classification of fishes, fossil and living, based upon the different types of scales, which were found to coincide to a remarkable degree with certain skeletal differences. His system was the first to recognize the ganoids as an independent order, although it is true that the limits assigned it were much larger than we can at present allow. However, Agassiz did not himself overestimate the value of his classification, being fully aware of its empiric character; but he committed himself to it chiefly on account of its great practical convenience. His aim was quite as much to prove the succession of fossil fishes throughout the different geological horizons as to work out their anatomical structure; and for this purpose, as well as for enabling him to bring together in an intelligible order large quantities of fragmentary material, it succeeded admirably. It may not be amiss to cite in this connection a letter of his to Humboldt, in which he disclaims attaching any special importance to his classification, and con-

[1] *Cf.* Alpheus Hyatt, On Cycle in the Life of the Individual (Ontogeny), and in the Evolution of its Own Group (Phylogeny). *Science*, N.S., vol. v (1897), pp. 161–171. Hyatt considers that "Agassiz's introduction of the element of succession in time laid the basis for all more recent [embryological] work" (p. 163).

tinues as follows: "My object was only to utilize certain structural characters which frequently recur among fossil forms, and which *might therefore enable me to determine remains hitherto considered of little value.*" [1]

Lastly, the *Poissons Fossiles* is notable for still constituting the most valuable repository of information we have on fossil fishes. In it are enumerated more than one thousand species, the greater part of which are accurately described and magnificently illustrated; and it is worth recording that the first successful application of chromolithography was in the execution of these plates. The fidelity of the drawings to nature and the minuteness of the accompanying descriptions have never ceased to challenge wonder and admiration.

Passing now for a moment to Agassiz's supplementary volume on the *Fishes of the Old Red Sandstone*, one cannot but feel amazement at the accuracy, cleverness, and originality of the author as displayed throughout this truly wonderful work. Greater difficulties were encountered in the way of studying the remains, which were scanty at best and imperfectly preserved; and more intricate problems presented themselves respecting the anatomy and homology of parts than any he had met with in the preparation of his larger work. True, the discovery of the Ludlow and Cromarty faunas was not a matter of long standing, but it had already engaged the attention of the most eminent British geologists and paleontologists, who were one and all confounded over the problematical organisms. But whether as a result of his training or intuition, or both, Agassiz had no hesitation in declaring, the moment he examined one of Hugh Miller's drawings and description of Pterichthys, that the creature was a chordate, and belonged to the class of fishes. His astonishment, however, on first seeing the actual fossils, is well told by himself in the preface to his monograph, as follows:

> I can never forget the impression produced upon me by the sight of these creatures, furnished with appendages resembling wings, yet belonging, as I had satisfied myself, to the class of fishes.... It is impossible to see aught more bizarre in all creation than the Pterichthyean genus; the same aston-

E. C. Agassiz, *loc. cit.*, p. 203.

ishment that Cuvier felt in examining the Plesiosaurus I myself experienced when Mr. H. Miller, the first discoverer of these fossils, showed me the specimens which he had collected in the Old Red Sandstone of Cromarty.

Any one who has attempted for himself to decipher the distorted and for the most part obscure remains from the Scottish Old Red can imagine the difficulties which the first students of such extraordinary forms labored under. He will understand that above all scrupulous refinement of observation is necessary; that innumerable comparisons and attentive reëxaminations of even the most tattered fragments must be made in order to test his hypothesis of the association of parts. Considering the means at Agassiz's disposal, his work must be pronounced nothing short of brilliant; it was remarkable alike for the originality and insight displayed, and for the general correctness of his conclusions. That some of his generalizations should have been premature was an inevitable consequence of pioneer work. And if, after more than fifty years, certain of his views are found to require modification, or to be no longer tenable, what more was to have been expected?

To cite one or two instances by way of illustration, let us suppose we grant with Cope that the Ostracodermi are not fishes, properly speaking, but belong to a group at the base of the craniate Vertebrata, characterized by the lack of a lower jaw and of paired limbs; how does that detract any from the unerring judgment of Agassiz, who pronounced them first of all to be chordates, and assigned them a place among the most primitive of ganoids? If we criticise his restorations of Pterichthys and Coccosteus as being crude and fanciful, we cannot accuse him, at all events, of misrepresentation. Just as it required the genius of a Traquair after many years of patient study to prove that the Platysomidæ are in no sense whatsoever related to the pycnodonts,[1] so, too, it required the combined efforts of the best Russian, German, and British talent to unravel the complicated structure of the coccosteids and ostracoderms. Tremendous advances have since been made, almost as a matter of course, but it was Agassiz who first clearly

[1] R. H. Traquair, On the Structure and Affinities of the Platysomidæ. *Trans. Roy. Soc. Edinburgh*, vol. xxix, 1879, pp. 343–391.

pointed out the way. Again, if it be said that Agassiz created numerous species on too slender grounds of distinction, does not this merely express the refinement of his personal equation in the art of discerning differences between allied forms of organisms, for which compensation is easily possible?

Aside from the classic works just noticed, Agassiz contributed very little to the subject of paleichthyology. A few minor papers appeared in different journals, or were appended to geological monographs by other authors (Murchison, de Verneuil, Keyserling, etc.), prior to his departure for America. In this country his attention was so diverted in other directions that he was unable to prosecute further original investigation. Some informal reports on fossil fishes were prepared by him at the meetings of the American Association for the Advancement of Science (at one of which, the Cincinnati meeting, in 1851, he offered some surprising comments on Macropetalichthys), and brief notes on the fishes of the Virginia Coalfield were contributed to Lyell's account of the geology of the basin in 1847. With these exceptions, the only paper from his pen on fossil fishes in America is that appended to the fifth volume of the Pacific Railroad Surveys,[1] published in 1856. It is also rather remarkable that he succeeded in interesting only one student of his to take up this line of research seriously; this was Mr. Orestes St. John, well known from his writings on Carboniferous fishes from Illinois and other western states.

Many have wondered why Agassiz, with all his wealth of information, his fertility of imagination, and after having discovered the very laws which constitute so important a bulwark in the theory of evolution, should persistently have opposed that doctrine, although his work on fossil fishes prepared the way for it most admirably. There can be no doubt that his mind was closed to such conclusions through the influence of preconceived ideas, on which it is unnecessary for us to dwell. His position with reference to the evolutionary hypothesis has been

[1] Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean. *Report of Explorations in California*, by Lieut. R. S. Williamson, vol. v, Washington, 1856. (Abstract of Agassiz's article in *Amer. Journ. Sci.* [2], vol. xxi, 1856, p. 274.)

so fittingly summarized by Le Conte[1] that we cannot do better, in conclusion, than heartily to indorse the following sentiments:

"There is something to us supremely grand in this refusal of Agassiz to accept the theory of evolution. The opportunity to become a leader of modern thought, the foremost man of the country, was in his hands, and he refused, because his religious, or perhaps better, his philosophic intuitions forbade. . . . A lesser man would have seen less clearly the higher truth, and accepted the lower. A greater man would have risen above the age, and seen that there was no conflict [between the theory of descent and still more certain truth], and so accepted both."

[1] Joseph Le Conte, *Evolution and its Relation to Religious Thought*, p. 45. New York, 1888.

AGASSIZ'S WORK ON THE EMBRYOLOGY OF THE TURTLE.

GERTRUDE C. DAVENPORT.

Agassiz's *Embryology of the Turtle* — the second volume in the series of *Contributions to the Natural History of the United States of America* (1857) — was for its time, and still remains in these days of refined histological technique, a beautiful and useful research. The scope of the book is broad. Stages in the development of the turtle are described, beginning with the most immature eggs in the ovary and continuing through many embryonic phases until the young turtle hatches out.

In addition to the great contribution to embryological knowledge which this book brought, it also contained much information of a sort too often unobserved or omitted by embryological investigators of to-day; namely, the habits, especially the breeding habits, of the animals studied.

Even to the present time we have almost no other printed accounts and none so complete to which we can turn for information in regard to the breeding time of and the number of eggs deposited by our commoner American turtles. Indeed, until Agassiz's time, and even to-day, it is believed by many that turtles lay in the fall as well as the spring. By careful observation upon turtles kept in comparative freedom and upon those in a wild state, Agassiz found that turtles deposit eggs once a year, normally in the months of May and June, the time depending upon the kind of turtle in question. Moreover, he determined the age at which various kinds of turtles begin to lay eggs and the time necessary for their hatching. These are only a few of the many interesting and useful facts regarding the life history of the turtle which this volume contains.

Agassiz's studies of ovarian eggs likewise disclosed many new facts. For example, the period of growth of ovarian eggs was determined. Ovarian eggs develop in sets corresponding in number to that of each laying. From the size and appearance of these ovarian sets, Agassiz was able to say

positively in what order at least four of the sets would be laid. His studies of ovarian eggs were, on the whole, excellent for his time, but his ideas in regard to yolk spheres differ considerably from those held to-day.

For our knowledge of segmentation stages we are indebted to Agassiz alone. Although the segmentation stages drawn in his beautiful plates or described by him do not form a complete series, nevertheless they remain the only ones observed by reptilian embryologists.

The next stage figured and described is that now generally known as the stage of the embryonic shield. The figures of this stage are beautiful and accurate, but what is now known to be the invagination of the primitive gut was mistaken for the beginning of the head development; in other words, the posterior end of the shield was mistaken for the anterior end.

Many individuals and stages in the subsequent embryological development are figured, and helpful descriptions of surface views are given. Those figures showing the vitelline and allantoidian circulations deserve especial mention.

The chapter and figures devoted to the development of organs contain much that is still useful to us. Indeed, his results are marvelous when we compare the methods of investigators of that day with those of our own. For we must remember that in Agassiz's time, imbedding in paraffin, the microtome, and, consequently, methods of reconstruction from sections were unknown. On the other hand, this absence of modern technique renders the chapter devoted to histology, however good for its time, of little scientific value for us to-day.

Eight plates are devoted to figures of the eggs and recently hatched embryos of all the commoner North American species of turtles. So accurately are these drawn that one can with certainty identify the species from the egg or newly hatched young. These plates alone render the work indispensable.

It is a tribute to the zeal and thoroughness of Agassiz and his helpers in this work that after forty years it stands to-day with its many unverified facts as an incentive to the reptilian embryologist to confirm and extend the work so magnificently begun.

AGASSIZ AT PENIKESE.[1]

BURT G. WILDER.

ELSEWHERE are set forth the characteristics and the achievements of Louis Agassiz as investigator and director of research, as accumulator of specimens and builder of museums, as writer and public lecturer. Whatever has been said of him also as inspirer of lofty effort and personal sacrifice, as teacher, and educational pioneer, surely the precious qualities implied in these terms were never more conspicuous or more effective than during the last year of his life in the establishment of the Anderson Summer School of Natural History at Penikese Island.

On the 14th of December, twelve months to a day before his death, was issued a circular embodying a "Programme of a Course of Instruction in Natural History, to be delivered by the Seaside, in Nantucket, during the Summer Months, chiefly designed for Teachers who propose to introduce the Study into their Schools and for Students preparing to become Teachers."

The following extract from a later circular clearly indicates the founder's views as to the nature of the enterprise:

[1] This article is based upon the writer's diary and recollections, and upon his article, "The Anderson School of Natural History," in the *Nation* for Sept. 11, 1873, pp. 174, 175. The doings of the first two days were described by a staff correspondent in the *New York Tribune* for July 9 and 10, 1873. In the *Popular Science Monthly*, vol. xl, pp. 721–729, April, 1892, under the title "Agassiz at Penikese," are recorded the impressions of the entire session upon a pupil, David S. Jordan. *The Organization and Progress of the Anderson School of Natural History at Penikese Island* (30 pp. and 5 ppl., Cambridge, 1874) is the "Report of the Trustees," of whom one was Alexander Agassiz, the professor's son; as a clear and accurate record of the essential facts it could not be surpassed. In *Louis Agassiz, His Life and Letters* (2 vols., Boston, 1885) Mrs. Agassiz has devoted the larger portion of the last chapter to what another biographer has characterized as "the most extraordinary episode in Agassiz's life." Upon the present occasion, under the necessary limitations of space, rather than a mere outline of the whole, the writer has endeavored to describe a few incidents that seem to him most characteristic of the occasion and of the man.

I must make hard work a condition of a continued connection with the school, and desire particularly to impress it upon the applicants for admission that Penikese Island is not to be regarded as a place of summer resort for relaxation. I do not propose to give much instruction in matters which may be learned from books. I want, on the contrary, to prepare those who shall attend to *observe for themselves*. I would therefore advise all those who wish only to be taught natural history in the way in which it is generally taught, by recitations, to give up their intention of joining the school.[1]

In the following spring the munificent offer by an utter stranger, Mr. John Anderson, of New York, of the island of Penikese in Buzzard's Bay, together with a dwelling-house and barn and an endowment of fifty thousand dollars, not only led to the change of location, but enabled Agassiz to carry out certain parts of his plan more fully.

The island was not formally in possession until April 22. Between that date and the 8th of July, when the school was announced to open, a site for buildings had to be chosen, plans drawn, contracts let, and provision made for the housing and subsistence of nearly fifty pupils and several instructors, some of them with families.

Notwithstanding the utmost efforts of all concerned, on the 5th of July, when Professor Agassiz and the writer reached the island, only one of the two projected buildings had been even roofed; it was neither floored nor shingled. The next day was Sunday. A few words from Agassiz satisfied the carpenters as

[1] The passages quoted above, and many that might be added from the circulars of Professor Agassiz, from his opening addresses, and from private letters and conversations, demonstrate conclusively that, while anticipating as an indirect result the increase of knowledge by research upon the part of the instructors and advanced pupils, the *primary object was instruction in fundamental facts, ideas, and methods;* he repeatedly declared his hope that the Anderson School might become the "educational branch of the Museum of Comparative Zoology." Whatever may have been his dreams for the future, and however extravagant may have been the declarations and prognostications in uninformed lay journals, at that time nothing was farther from his mind than any comparison with, *e.g.*, the Zoological Station at Naples. The fact of his clear recognition of the distinction is insisted upon here in the interests of simple justice towards Professor Agassiz, his associates, and pupils. Those who may regard this insistence as needless are referred to the article "An American Seaside Laboratory" in *Nature* for March 25, 1880, pp. 497–499, and to the commentary thereon, "The Penikese School," in the *Nation* for July 8, 1880, p. 29.

to the application of the proverb, *Laborare est orare*, and they worked from daylight till dark. On Monday (for the steward and servants were to come with the pupils) the floor was swept, and Tuesday morning the beds were made by Mrs. Agassiz and the writer's wife. That morning, also, the cows were removed from Mr. Anderson's barn; the last nails of a new floor were hardly driven when the steamer arrived, and in that room, still hung with spider webs and frequented by the swallows, were delivered the inaugural address and eaten the first dinner at Penikese.

The invitation of Professor Agassiz to coöperate in the work of the school had been accepted by about twenty, and it is pleasant to note that, with hardly an exception, their services were freely offered, although liberal arrangements were afterwards made with those who, in addition to Professors Agassiz and Guyot and Count Pourtalès, actually gave instruction. These were Edwin Bicknell, T. I. F. Brewer, B. Waterhouse Hawkins, A. S. Packard, Paulus Roetter, and the writer.

The roll of pupils is printed on pages 19–20 of the *Report of the Trustees* for 1874; it is here reproduced, alphabetically arranged, and with the addition, in parentheses, of the present official positions so far as known to the writer. Those known to have died are indicated by an asterisk.

ADAMS, CH. F., Teacher in High School, Fitchburg, Mass.

APGAR, A. C., Teacher in State Normal School, Trenton, N. J.

BEAMAN, MARY E., Teacher in High School, Binghamton, N. Y.

BOWEN, SUSAN, Teacher in Mount Holyoke Seminary, South Hadley, Mass.

BROOKS, W. K., Teacher, Cleveland, Ohio (Professor of Zoology in Johns Hopkins University).

BURNS, Mrs. V., Teacher in Public School, Pittsburg, Pa.

CLAYPOLE, E. W., Professor at Antioch College, Yellow Springs, Ohio (Professor of Natural History, Buchtel College).

COFFIN, HELEN B., Teacher in Eastern State Normal School, Castine, Me.

COLE, CAROLINE J., Teacher in State Normal School, Salem, Mass.

COOK, S. R., Teacher in Packer College Institute, Brooklyn, N. Y.

CROSBY, EUGENE C., Teacher, Kansas City, Mo.

CROSBY, W. O., Student in Boston School of Technology (Assistant Professor of Geology, Massachusetts Institute of Technology).

DAVIS, MARY E., Teacher in High School, East Somerville, Mass.

FAXON, WALTER, Instructor in Museum of Comparative Zoology, Cambridge, Mass. (Assistant in charge of the Museum).

FERNALD, CH. H., Professor, Maine State College, Orono, Me. (Professor of Zoology, Massachusetts Agricultural College, Amherst).

FEUKES, J. WALTER, Student at Harvard College, Newton, Mass. (Zoologist and Ethnologist, Washington, D. C.).

GARMAN, S. W., Museum of Comparative Zoology, Cambridge, Mass. (Assistant in Herpetology and Ichthyology in the same).

GASTMAN, E. A., Superintendent of Public Schools, Decatur, Ill.

HALE, SILAS W., Principal of High School, Milford, Mass.

HALL, CHARLES E., State Museum of Natural History, Albany, N. Y.

HANSON, M. ISABEL, Newton Training School, Newtonville, Mass.

HOLMAN, LAVINIA, Teacher in Normal School, New York City, N. Y.

HOOPER, F. W., Student at Harvard College, Walpole, N.H. (Director of Brooklyn Institute).

INGERSOLL, ERNEST, Museum of Comparative Zoology, Cambridge, Mass. (Ornithologist and Author).

IRELAND, CATHERINE, Teacher of Private School, Boston, Mass.

JOHNSON, AMY, Teacher in Brooks Seminary, Poughkeepsie, N. Y.

*JOHONNOT, JAMES, Teacher in State Normal School, Warrensburg, Mo.

JOHONNOT, MARION, Teacher in State Normal School, Warrensburg, Mo.

JORDAN, DAVID S., Instructor in Botany, Appleton, Wis. (President of the Leland Stanford Junior University).

MILLER, A. B., Teacher in Maplewood Institute.

MINOT, CHARLES S., Zoological Student, Jamaica Plains, Mass. (Professor of Histology and Human Embryology, Harvard Medical School).

MOSES, THOMAS F., Teacher of Natural Science, Urbana, Ohio (Professor of Natural History, Urbana University).

REID, ZELLA, Antioch College, Salem, Ind.

SCOTT, J. G., Teacher in Normal School, Westfield, Mass.

SHATTUCK, LYDIA, Teacher in Mount Holyoke Seminary, South Hadley, Mass.

SMITH, SARAH R., Teacher in Chauncy Hall School, Boston, Mass.

STOWELL, T. B., Professor in State Normal School, Cortland, N. Y. (Principal of the State Normal School, Potsdam, N. Y.).[1]

*STRAIGHT, H. H., Teacher in State Normal School, Warrensburg, Mo. (Professor of Natural History, State Normal School, Oswego, N. Y.).

*STRAIGHT, Mrs. EMMA, Teacher in State Normal School, Warrensburg, Mo.

TINGLEY, J., Teacher in Alleghany College, Meadville, Pa.

WHIPPLE, ELLIOT, Principal of Academy, Bunker Hill, Ill.

WHITE, MARY R., Teacher in Training School, New Bedford, Mass.

[1] Although not registered as a student, Mrs. T. B. Stowell accompanied her husband and coöperated efficiently in his work.

WHITMAN, C. O., Teacher in English High School, Boston, Mass. (Head Professor of Biology, University of Chicago, Ill.).

WHITNEY, SOLON, Teacher in Cambridge High School, Watertown, Mass.

It is significant that at least six of those who attended the first summer school of natural history in America have been more or less directly concerned in the development of its improved successors in various parts of the country.

Of the forty-four persons on the above list, sixteen — more than one-third — were women. Coeducation — then hotly debated and regarded in some quarters as a bugbear — had not, apparently, with Agassiz even the dignity of existence as a problem. In his opening address the matter was disposed of in the following words:

> As soon as the number of students was limited, we determined a question of no small moment, — whether ladies should be admitted. In my mind I had no hesitation from the start. There were those about us whose opinion I had to care for but did not know, so I thought the best way was not to ask it, but to decide for myself.

His decision was certainly consistent. The title of his thesis at graduation in 1830 was "*Femina humana mari superior.*"[1] For several years he had lectured almost daily in a school for girls conducted by his wife; and upon her intellectual companionship and coöperation he had become so dependent that he once declared to the writer with signs of profound emotion, "Without her I could not exist." Nor was his confidence in the desire and capacity of those women misplaced. With hardly an exception, their assiduity was notable, and they, rather than the men, required warning against overwork during what should have been their time of rest or recreation.

The age and position of most of the students and the circumstances under which they were placed precluded any expectation of disorder. The single untoward incident is mentioned as illustrating two of Agassiz's characteristics, *viz.*, his hopeful willingness to afford individuals the benefit of any

[1] So stated in Guyot's *Memoir of Louis Agassiz*, p. 17. Read before the National Academy of Sciences, 1877 and 1878. Princeton, 1883. 49 pp.

doubt in their favor and his clear perception of the injustice of permitting an institution to suffer from the presence of such as prove unworthy of confidence. Among the men first admitted were three whose ancestry led Agassiz to overlook their youth and lack of experience as teachers. Early in the session they committed a breach of decorum which some might regard as amusing or as exemplifying the infallibility of the comfortable doctrine, "Boys will be boys." The next morning Agassiz simply announced that three young men had shown themselves undeserving and would leave the island before noon. What an object lesson in disciplinary methods for timid faculties!

The pupils, of whom, it will be remembered, nearly all were themselves teachers of more or less experience, proposed to form an "Agassiz Natural History Club" for mutual benefit. The instructors were invited to attend as honorary members. At one of the earlier meetings an afternoon was spent in elaborating a constitution, electing officers, etc. Agassiz sat silent and apparently motionless, but those nearest him could detect signs of increasing impatience, and when invited to address the club he spoke substantially as follows:

> Gentlemen, — I had heard that Americans are famous for the perfection of their organizations, and of course order must be maintained in every association. But at best officers and by-laws are necessary evils. We shall not be many days together; surely part of this afternoon might have been better spent in the reading and discussion of papers. At any rate, that is what we should have done in Switzerland.

At the close of another meeting of the society Agassiz remained seated for some time as if reflecting, and when at length he rose and moved away it was with unwonted deliberation. On being questioned he replied, "I sat so long because I was not sure that I could walk. At times I realize that I am growing old and that I have not always used my strength wisely." Upon another occasion (recorded in my diary as August 8), referring to the recent death of a museum assistant (Dr. Maack), he said, "My time will come soon, and I am ready." Yet before his associates and pupils he main-

tained always a cheerful demeanor, and none suspected his condition to be such that his wife watched him with increasing anxiety, and during her occasional absences arranged a simple signal between his room and mine (directly below) which should notify me of his sudden illness or need of aid.

Saturday, the 26th of July, was a red-letter day for all. Minor events were the collection of a Gunellus, an Echineis, two rays, and one shark; the brains of all were exposed, compared by the class, and then preserved. The finding of eggs in the oviducts on both sides of a ray caused Agassiz great joy, while to most of us, hailing, as we did, from "fresh-water" institutions, it was a kind of revelation. But the crowning event was the arrival of Arnold Guyot, Agassiz's fellow-student, collaborator, and life-long friend. Strongly contrasted in certain respects, but both eminently handsome, as they strolled about the island with arms thrown over each other's shoulders, they made a picture at once charming and majestic and never to be effaced. They were united even in their discourses. Naturally, the advent of Guyot made glaciers a leading topic, and at a pause in the lecture of either the other would interpolate, "No, Louis," or "Yes, Arnold; don't you remember so and so?" etc. Indeed, the presence of Guyot constituted a natural climax to the scientific idyl at Penikese.

Yet the delightful spirit of the time and place did not preclude hard work. From morning to night and during the evening all were occupied. Whether guiding or following, imparting or receiving, demonstrating or observing, instructors and pupils alike were striving to increase both their own knowledge and that of others; nor does there rise in my memory a single instance of self-seeking upon the part of any connected with the school.

How else could it be with the example of the master ever before us? No longer young, exhausted not so much by work (although that had often been excessive) as by responsibilities and uncongenial administrative duties, commanding from one hundred to five hundred dollars for a single public lecture, yet often with "no time" to that end, at Penikese he lectured almost daily, sometimes twice a day, and was an attentive lis-

tener to the instruction of his associates. In the laboratory or in the field encouragement and inspiration emanated from him. In our minds he appeared encompassed by a halo of self-sacrifice that would have been only larger and more radiant could we have foreseen the impending result of his labors.

The situation has been feelingly described by one who could most keenly appreciate it:

> It was to me supremely touching to see the great naturalist at Penikese a few months before his death devoting his last strength to a crowd of eager learners, directing them to the exclusive study of the book of nature, and showing them, by word and deed, how to observe it and how to be taught by these living realities.[1]

Even had the future been revealed to Agassiz, it may well be doubted whether his efforts would have relaxed. A surprising benefaction had enabled him to materialize a long-cherished educational ideal, and he might have chosen deliberately to consecrate thereto the last summer of his life. In establishing, within three months, upon an uninhabited island not readily accessible, an institution where teachers — men and women alike — were led from the consultation of books to the personal interrogation of Nature, Agassiz not merely overcame the inertia of matter and the apparent limitations of time and space; like another Swiss, upon a different field, he gathered to his devoted breast the spears of ignorance and indifference, of covert ridicule and open opposition, and made way for the advance of knowledge along paths till then unbroken. "Peace hath her victories no less than War."

Yet had there been no such material outcome as the many summer schools since established, all connected with the Anderson School in 1873 will regard those weeks as an epoch in their lives; to their pupils and to their pupils' pupils forever will be transmitted the story of what was said and done, seen and heard while they had the honor and the happiness of being with Agassiz at Penikese.

[1] Guyot, *Memoir of Louis Agassiz*, p. 46.

EDITORIALS.

March, 1848, the Beginning of a New Era in the History of Zoology in America. — It is interesting to review the condition of the natural sciences, and especially of zoology, in the United States half a century ago. The pioneers of those days are rapidly passing away, but the records of the societies, the journals, and the isolated books give one, in outlines at least, the status of zoology, while the reminiscences of the older men give the picture vitality. Looking over these old pages and numbering the stories the fathers have told us, we can conjure up, more or less vividly, those primitive days with their inadequate library facilities, their small museums supported only by the greatest self-sacrifice of the few, and also the low esteem in which "bug-hunters" were held by the general public. Indeed, it was at a much later date that Stimpson, hunting for shells in the refuse brought in by the fishermen, was stoned as a crazy man by the men and boys of Marblehead.

From such a review one becomes impressed with the fact that the zoology of that day was not held in high esteem by the colleges, but existed apart from them. There was, it is true, something taught that was labeled zoology in a few institutions. Baird was teaching in Carlisle, Dana at New Haven, Emmons at Williams, and Adams at Middlebury, and earlier still Rafinesque held a chair in Transylvania University in Kentucky, while Nuttall for a few years gave private instruction to a few students at Harvard. As one turns over the pages in which Adams described the shells of Jamaica and of Panama he cannot but wonder at the nature of the instruction in those days. How could it have had any human interest for the student? These exceptions aside, the great proportion of the natural history work of the country was done by men without academic position, and largely by physicians in moments snatched from a busy practice. Indeed, it was regarded as the proper training for the profession of a naturalist to begin with the study of medicine, and the present writer was advised not twenty-five years ago to attend a medical school as an introduction to the study of zoology.

There were then two great zoological centres in America, — Boston and Philadelphia. In Boston the leaders were Binney, Gould, Storer, Wyman, Cabot, Harris, Jackson, Bryant, Brown, and Couthouy;

at Philadelphia the work was being done by Morton, the two Leas, Peale, Conrad, Haldemann, Leidy, and Wilson; and it is a noticeable fact that in this catalogue of names all but two — Leidy and Wyman — were systematic zoologists pure and simple. This fact is but characteristic of the times. It was the day of species describing. There was a wealth of undescribed forms, and the recently organized state surveys, as well as the government expeditions, were daily bringing in new forms to describe, new species to catalogue. When we leave these two cities we find the zoological devotees scattered here and there throughout the country: Mighels at Portland, Wheatland and Cole at Salem, Nichols at Danvers, Tufts at Lynn, Dana and Ayres at New Haven, Fitch at Salem, N.Y., Bailey at West Point, Dekay at New York, Holbrook, Bachmann, Gibbes, and Ravenel at Charleston, Hentz in Florence, Ala., and Kirtland at Cleveland. That curious zoological centre at New Harmony had already broken up and its members were scattered or dead.

The means of publication were few, and the bulk of the zoological papers appeared in the records of the societies of Boston and Philadelphia, two in either city. Besides these there were publishing societies in New York and Salem, while other places, like Hartford, published one or two numbers and then passed out of the scientific world. The only strictly scientific periodical was the *American Journal of Science and Arts*, although now and then a magazine like the *Naturalist* of Boston ran a brief course. It necessarily followed that many a scientific paper was forced into the medical and agricultural journals and buried there almost beyond hope of resurrection. There was but one other means of getting results into print and that was open to but the few. We refer to the State Surveys which came into existence but a short time before, the publications of which reached their scientific height in the survey of Massachusetts, but were published in the most sumptuous form by the state of New York.

Such in outline was the condition of zoology in America half a century ago. It was almost entirely what we now know as systematic zoology and it was all but ignored by the colleges, all of whose energies were turned in the direction of the classics, mathematics, and metaphysics. The times were ripe for a change. In the records of Harvard University is to be found the following minute:

"At a stated meeting of the President and Fellows of Harvard College in Boston, Sept. 25, 1847. Present, President Everett, Dr. Walker, Mr. Lowell, Mr. Curtis, Treasurer Eliot.

"*Voted:* That this board do now proceed to the election of a Professor of Zoology and Geology in the Lawrence Scientific School in the University at Cambridge. Whereupon, ballots being given in, it appeared that Professor Louis Agassiz, late of Neuchâtel, Switzerland, was chosen.

"*Voted:* That the President be requested to lay this election before the Board of Overseers, that they may concur in the same if they see fit."

According to the statement in Marcou's *Life of Agassiz*, we are led to infer that this appointment was accepted in February, 1848. In March Agassiz began his instruction at Harvard, and with it there began a new era in zoological science in America. Anatomy and embryology were henceforth to assume their proper position, and this country was to advance along new lines, until now in morphological science it stands second only to Germany among the nations of the earth. It seems, therefore, peculiarly fitting that the *American Naturalist*, founded as it was by four pupils of Professor Agassiz, — Alpheus Hyatt, Edward Sylvester Morse, Alpheus Spring Packard, and Frederick Ward Putnam, — should pay some attention to the fiftieth anniversary of Agassiz's appearance as a teacher in America, — an anniversary which indicates not only a change in the character of zoological science in America, but as well a change in the academic position of zoology in our educational institutions. We therefore present in the foregoing pages a sketch of the life of Agassiz and reviews of some aspects of his work, kindly written at our request for this occasion.

The Fur-Seal Problem. — We are very glad to see in two or three recent numbers of *Natural Science* editorials upon the fur-seal problem in which the necessity of prohibition of pelagic sealing is admitted, if the herds of the Pribilov and Commander Islands are not to be exterminated. In fact, this journal fully supports the contention of the government of the United States. This is no more than could be expected from a scientific journal. The whole problem of the fur seal is a question of fact, and these facts are capable of but one interpretation, unless they be garbled, as was recently done by one Englishman high in authority. In a word, the position of the British government is indefensible; but it is hardly possible to hope for any sensible arrangements until there is a change in the personnel of those who are directing the British Empire.

REVIEWS OF RECENT LITERATURE.

History of the Smithsonian Institution.[1] — The Smithsonian Institution has been so intimately associated with the progress of natural science in the United States during the last fifty years that its history is a sort of epitome of the activities of American naturalists during that period.

It originated in a bequest of James Smithson, of England, who, dying in 1829, left his property to his nephew with the provision that, in case he died without heirs, it should go "to the United States of America, to found at Washington, under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men." His nephew dying soon after, the property, amounting to over $500,000, was paid to the government, which guaranteed forever to the institution interest at the rate of six per cent on the original sum, together with all savings and gifts added to it, to the amount of $1,000,000. The total principal is now over $900,000.

The bequest being without precedent, a protracted discussion occurred as to the best way to use the fund. A university, an astronomical observatory, an agricultural experiment station, and a meteorological bureau were urged by different persons. At about this time a society called the National Institute was organized at Washington, rapidly gained a national reputation, and made great, but vain, efforts to get Congress to unite the Smithsonian Institution with it. The opposition of Congress led to the quick decay of this society, but it, more than anything else, determined the character of the Smithsonian Institution when, in 1846, it was finally established.

The character of an institution is often determined more by its earliest executive than by its statutes. The pride American men of science take in the "Smithsonian" is largely due to what Joseph Henry was and what he made it during its first thirty-one years. The particular interest that naturalists feel in the institution is largely due to the second secretary, the zoologist Baird, who admirably complemented the work of Henry.

[1] *The Smithsonian Institution, 1846–96. The History of its First Half-Century.* Edited by George Brown Goode. Washington, 1897. 856 pp.

In considering the special lines of work of the institution most interesting to naturalists, we may refer briefly to the National Museum, the Bureau of Ethnology, the Exchange System, the Zoological Park, and Explorations.

The museum was a cherished feature of the "National Institute." It had been given charge of the collection of the Wilkes' Expedition, 1838, and when it broke up, this collection and the others it possessed passed to the Smithsonian Institution. The exploration of the Territories and donations from foreign governments and from travelers soon swelled the collections enormously, so that now a special congressional appropriation of over $180,000 per annum is required to maintain them.

The Bureau of Ethnology, which had its germ in Major Powell's explorations of the canyons of the Colorado and of this whole river basin, 1867–69, and had passed an embryonic existence under the "Geographical and Geological Survey of the Territories," was born as a distinct bureau when the Geological Surveys were reorganized in 1879.

The System of International Exchanges was proposed by Henry, 1847, in his original plan of organization. Originally it related only to the exchange of government publications; but later the service was extended to the international exchange of publications between scientific societies or between societies and individuals. This work has grown so that it now requires a special congressional appropriation of $17,000 per annum.

The National Zoological Park, which originated over ten years ago in Secretary Langley's desire that the National Museum should possess living animals, now includes 166 acres in the suburbs of Washington. While the great expense of its maintenance precludes its rapid growth, it is believed to be already an important safeguard against the utter extinction of several species of mammals.

As for explorations, the Smithsonian Institution has coöperated in all those of the government since 1846 and has granted subsidies to some private ones. The decade preceding 1856 was very fertile in government surveys. Among these may be mentioned the survey of Wisconsin, Iowa, Minnesota, etc., by Owen, of the Lake Superior region by Jackson and Whitney, of Oregon by Evans; the survey of the boundary between the United States and Mexico, and later of the Gadsen Purchase; the Pacific Railroad surveys along the 47th parallel, the 41st parallel, the 38th and 39th parallels, the 35th parallel, the 32d parallel, in California, and in Northern California

and Oregon; explorations of the Red River, the Great Salt Lake, the Upper Missouri and Yellowstone, and the survey of the Indian Territory; naval expeditions to Chile, Japan (Perry), the China seas and Bering's Strait, La Plata and its tributaries (Page), the west coast of Greenland and Smith's Sound (Kane). Later, under Baird, the institution coöperated with the marine explorations of the Fish Commission. Among private explorations aided were those of the American Antiquarian Society of Worcester, Mass., among Ohio mounds, 1851; of Samuels in California, 1855; of Kennicott in British America and Alaska; of Dall in Alaska; of Scott in Yucatan; of Berendt in British Honduras, 1865; of Orton in northern South America, 1867; of Simson in Utah, 1859; of Stejneger at the Commander Islands, 1882; of Jouy in Corea, 1883; of Rockhill in Mongolia and Thibet, 1888–89, 1891–92. Such explorations have affected not only science, but commerce.

Finally, a few words may be said about the work done in the publication of zoological and botanical investigations alone. Among zoological works we notice Scudder's *Nomenclator Zoologicus;* numerous works on zoogeography; descriptive, monographic, and faunistic works, issued either as separate "Contributions" or in the *Proceedings of the U. S. National Museum;* and a few physiological memoirs.

To these may be added valuable reports on *The Progress of Zoology, 1879–86*, and *Instructions for Collectors.* Among botanical works are the results of Wright's explorations in Texas; several expensive monographs by Torrey and by Gray, especially Gray's *Synoptical Flora of North America*, Harvey's *Marine Algæ of the United States*, Wood's *Fresh-Water Algæ*, and Leidy's *Fauna and Flora within Living Animals.*

This brief review of some of the chapters of the history which lies before us inadequately indicates its scope and value. The volume was planned and partly carried to consummation by the late Dr. G. Brown Goode. The reading of the book impresses one strongly with the single-mindedness of those who have been chiefly concerned in the management of the Smithsonian Institution.

C. B. D.

Proceedings of the Indiana Academy of Science. — The volume of the *Proceedings of the Indiana Academy of Science for 1896*, dated 1897, did not reach our hands until the last of January, 1898. The volume is a larger one than its predecessors, and, like them, is an example of printing done at state expense, — a pretty poor example of typographic art. Another fault we have to find with the

work is the absence of any real table of contents, the result being that it is very difficult to refer to the papers. Aside from this the volume is up to its usual standard. Among the more important papers within the scope of our pages are the following: one by Mr. Call upon the maps of Mammoth Cave, from which we learn that no really accurate map of the cave exists, the reason probably being that the owners are afraid that some one will tap their property and force them to divide the enormous admission price charged. Professor Burrage tells us that the water supply of Lafayette has been affected by Uroglena. Messrs. Hessler, Blatchley, Chipman, S. Coulter, Arthur, and Snyder give lists of additions to the flora of the state, and Miss Cunningham revises the species of Plantago of the United States. Miss Cunningham has studied the effects of drought upon the tissues of several cultivated plants, while M. B. Thomas repeats well-known statements regarding periodicity of root pressure. Messrs. Bitting and Davis have studied the bacteria of stables, and Miss Golden concludes that common yeasts have little or no pathogenic properties.

In the zoological field Mr. Rittger gives in outline a study of a digenic trematode found in pond snails and artificially fed to ducks, in which the adult condition was obtained. Mr. Butler adds to the list of Indiana birds and gives a detailed account of the bobolink within the state. Mr. Call gives an account of the aquatic mollusca of the state, and their relations to the river basins; 195 species are enumerated, and of these 130 are reported from the Wabash basin and 127 from the Ohio. B. M. Davis gives a poorly arranged, but nearly complete, bibliography of the pineal structures. Dr. J. R. Slonaker presents an abstract of his paper on the fovea of the eye, printed in full in the *Journal of Morphology*.

The study of the lakes, so prominent in other volumes of these proceedings, is largely ignored in the present volume, while geology and archeology are represented by but few papers. Dr. Moore gives an account, with a plate, of the Randolph County mastodon, now in the possession of Earlham College.

ANTHROPOLOGY.

The Races of Europe. — Dr. J. Deniker, in the *Bulletin of the Society of Anthropology of Paris*,[1] presents a "second preliminary

[1] *Les race de l'Europe*, tome viii, No. 4, p. 291.

communication" relating to his researches upon the races of Europe. A provisional classification is offered, subject to modification if necessary, as the investigation continues. This classification is based solely upon somatological characters at present. By taking three characters, as the cephalic index, stature, and color, and dividing each into three degrees, twenty-seven combinations are possible. Deniker's researches demonstrate the existence of six clearly marked combinations and four of less prominence. He therefore divides the people of Europe into six principal and four secondary races. For convenience of reference, I have formulated the following table from his detailed descriptions:

NAME (as given by Deniker).	COLORATION.	CEPHALIC INDEX.	STATURE.	
1. *Race Nordique*	Blond	72 to 78	1.72 M	Corresponding to the Germanic, Cymric, or Reihengräber race of certain anthropologists.
2. *Race Orientale*	Blond	82 to 83	1.63 to 1.64	Includes the Bielorouses, certain Lithuanians, etc.
3. *Ibero-insulaire*	Brunette	74 to 75	1.61 to 1.62	Spanish Peninsula, Sardinia, Sicily, etc.
4. *Occidentale* or *Cévennole*	Brunette	85 to 87	1.63 to 1.64	The Celtic, Celto-ligurian, Celto-slave, or Alpine race of various anthropologists.
5. *Race Littorale* or *Atlanto-méditerranéenne*	Brunette	79 to 80	1.66	Atlantic and Mediterranean coasts.
6. *Adriatique* or *Dinarique*	Brunette	85 to 86	1.69 to 1.71	Extending with interruptions from Belgium to Croatia.

Prof. W. Z. Ripley, in his paper upon "The Aryan Question,"[1] divides the races of Europe into three groups, according to their cephalic index and other physical characters. The Mediterranean and Teutonic types are derived from that paleolithic long-headed race which first occupied western Europe. Later a round-headed race of "decidedly Asiatic affinities" invaded the country. They are most nearly represented at the present time by the Alpine or Celtic type of central Europe.

[1] The Racial Geography of Europe. Appleton's *Pop. Sci. Mon.*, vol. lii, p. 304.

Dr. Deniker believes that he has established a basis upon which to build deductions from the facts relating to archæology, topography, linguistics, etc. It will be noticed that his preliminary conclusions differ materially from the final results of Professor Ripley's careful studies. We shall await with interest for further accounts of Dr. Deniker's work; it may assist in establishing the true value of the data upon which the Anthropo-sociologists, Ammon, Lapouge, and all "these head fellows" depend. At present this mathematical method seems to be too seductively easy.

FRANK RUSSELL.

ZOOLOGY.

The Development of Fresh-Water Bryozoa.[1] — Another grand quarto on fresh-water Bryozoa by Braem. As many observations of broad interest are included in this work, it is desirable that especial attention should be directed to them.

Spermatogenesis. The spermatogonia contain a large nucleus with one or two nucleoli and a "Nebenkern." The number of chromosomes in the first division was not exactly made out; it was between twelve and sixteen. During the second division the number is smaller (six to eight), so that the first is doubtless the reducing division. The cytoplasms of a large number of spermatids fuse into a single mass; the axial filaments of the tails arise and are of cytoplasmic origin; the neck is formed by the aggregation at one point of microsomes that were previously scattered all about the nucleus; the head arises from the nucleus in that the chromatin first accumulates at one pole, then the nuclear sap is eliminated, and the whole body becomes smaller and dense. An erythrophile substance also passes from the nucleus into the cytoplasm.

The ovarian eggs have a nucleolus which is often dumb-bell-shaped or double and contains one or more contracting vacuoles. The cytoplasm exhibits two concentric zones, of which the outer contains large, deeply staining granules of unknown origin. Maturation stages were not observed.

Fertilization takes place in the ovary. The egg then passes into an "oœcium," — a modified polypide, — to the wall of which the ovary may be said potentially to belong.

[1] Braem, F., Die geschlechtliche Entwickelung von Plumatella fungosa. Zoologica, Heft 23, 96 pp., 8 plates.

Cleavage was traced to thirty-two cells, which remain broadly united to one another at the centre of the whole mass. The extraordinary conclusion is reached that some of the deeply staining ("chromatic") bodies of the outer zone of the egg form, during its first cleavage, nuclei, which have, however, no further rôle.

Gastrulation and mesoderm-formation, long misunderstood, are cleared up. In the 32-cell stage, four cells enter the blastula cavity at the upper pole; they represent the entoderm. This degenerates, and a pseudo-blastula results. An ingression of cells at the upper pole of the now much larger embryo follows: this is the mesoderm-formation. Thus the primitive entoderm is wholly rudimentary.

The pair of *primitive polypides* also arise at the upper pole and the larva is soon thereafter born. The position of the primary polypides seems reversed in Gymnolæmata and Endoprocta as compared with Phylactolæmata, for in the former groups this polypide arises at the pole at which gastrulation occurs.

In regard to the *law of sequence of buds*, Braem insists on the wide difference between the budding of Phylactolæmata and Gymnolæmata, since new polypides arise on the oral side of the old ones in the former, and on the anal side in the latter group. He forgets, however, that in both groups the anal side of the young bud is turned towards the source of its tissue.

The work before us is destined to become a classic. The typography is of the best. Eight quarto plates, by Werner and Winter, contain drawings which, while trustworthy, are almost diagrammatically clear. C. B. D.

Lepidosiren. — From *Natural Science* we learn some facts regarding the development of the dipnoan, Lepidosiren, of Paraguay. Mr. J. Graham Kerr, of Cambridge, aided by a grant from the Balfour fund, went to Paraguay to obtain material for a history of this animal, and apparently was very successful in his search. Lepidosiren occurs in considerable numbers in the swamps, is rather sluggish, and comes to the surface at short intervals for respiration. Its food consists of the large snail, Ampullaria, and of confervoid algæ, the young being more vegetarian in their diet than are the adults. The animal makes a burrow in the ground at the bottom of the swamp, lines it with soft grass, and in it deposits her eggs. These eggs are very large, about 7 mm. in diameter, and, in the developing eggs, have a thin and horny coat, derived from a gelatinous coat which surrounds the eggs before oviposition. The segmentation is holoblastic and

unequal, and the process of gastrulation recalls that of the urodeles and cyclostomes. From the egg there hatches a tadpole which develops external gills and a very large sucker of the amphibian type. Both suckers and external gills disappear in about six weeks after hatching, but not until ten or twelve weeks does the larva feed for itself, living up to that time upon the yolk. During the breeding season the papillæ on the hind limbs of the male grow out into long blood-red filaments, apparently ornamental in nature. In the night the normally dark color of these animals changes to nearly white, the black chromatophores being retracted in darkness. In the dry season Lepidosiren behaves much like Protopterus, retreating into the mud and breathing by means of an air hole.

From this brief outline it would appear that Lepidosiren presents considerable similarity in its development to Ceratodus, as made known to us by the investigations of Semon.[1] The eggs in this form measure 6.5–7 mm. in diameter; segmentation and gastrulation are much the same, but in Ceratodus the envelope is gelatinous, while neither suckers nor external gills are developed. The similarities of both of these dipnoans to the Amphibia in their external development is very striking, but this does not of necessity imply any close relationship between the two groups. One recalls in this connection the larval forms of Lepidosteus, as described by Agassiz, and of Amia, as figured by Allis and by Dean.

Fishes of the Vicinity of New York City.— Mr. Eugene Smith has just published an excellent list of "the fishes of the fresh and brackish waters in the vicinity of New York City" in the *Proceedings of the Linnæan Society of New York.*

The list comprises 61 species, 24 being native fresh-water species, 11 introduced species, and 26 belonging to brackish waters or running up the rivers to spawn. The list is accompanied by brief but accurate descriptions and by useful notes on the local distribution. The work is neatly and correctly done, and should be followed by an equally exact list of the marine fishes of the same region. Curiously enough, our knowledge of the local fish fauna of New York Bay is still incomplete. D. S. J.

[1] *Jena. Denkschriften*, Bd. iv, 1893.

BOTANY.

Ripening of Fleshy Fruits. — Mr. C. Gerber contributes a paper of 280 pages on this subject to *Ann. d. Sci. Nat. Bot.*, 8th ser., tome iv, nos. 1–6, 2 pl. He studied the behavior of many fruits, — apples, pears, peaches, plums, grapes, oranges, lemons, melons, medlars, loquats, persimmons, bananas, etc. In the space of a short review it is possible to mention only a few of the many interesting facts set forth. Some of the changes which take place in the ripening of fruits are :

(1) The acids, malic, tartaric, citric, are partially used up in the formation of carbohydrates.

(2) The tannin disappears by complete oxidation, without forming any carbohydrates.

(3) The starch is transformed into sugar.

(4) The saccharine substances partly disappear by oxidation.

Mr. Gerber finds that the odors of certain fruits are due to the asphyxiation of the cells, alcohols and volatile acids (acetic, formic, etc.) being formed and these uniting to form agreeable ethers. The asphyxiation of the ripening fruits is due to the development of pectin, which swells, closes up the intercellular spaces, and shuts out the air. If the fruits are then kept at a sufficiently high temperature, so that the life processes of the cells go on rapidly, more oxygen is necessary than can filter through the swollen tissues and that in the sugar is drawn upon, but only after the tannin has entirely disappeared, *i.e.*, the sugar is broken down with the formation of acids and alcohols (and subsequently of ethers) and the liberation of carbon dioxide. At lower temperatures the cells of the fruits are able to get the small amount of oxygen required for their life processes from the air, and consequently no volatile acids, alcohols, or ethers are formed. This is why such fruits as persimmons and bananas are destitute of odor when ripened in cool places. The facts of respiration are as follows :

(1) Sweet fleshy fruits in certain phases of their development liberate in a given time a volume of carbon dioxide greater than the oxygen absorbed, so that the respiratory quotient $\left(\frac{CO_2}{O}\right)$ is greater than unity.

(2) This special respiratory quotient has a different origin and progress, according to the stage of ripening and the chemical principles in the fruits. Two kinds of quotients superior to unity are

distinguishable, one due to the presence of acids, the other to the lack of air and the resultant production of alcohol.

(3) The quotients of acids occur whenever fruits containing these acids (citric, tartaric, malic, etc.) are exposed to a sufficiently high temperature, — 30° C. and upwards for fruits containing citric and tartaric acid, 15° C. and upwards for fruits containing malic acid. Quotients of acids are also found in fatty plants.

(4) The quotients of fermentation are produced whenever the oxygen of the air fails to reach the cells in sufficient quantity to furnish the energy necessary for vital activity.

(5) The quotient of fermentation differs from the quotient of acids in the following ways :

(*a*) By the time it appears, — end of maturity.

(*b*) By the lower temperature at which it can take place, — even at 0° C. in case of some fruits.

(*c*) By its value, — often above 3, while that of acids is always below 2 and generally less than 1.5.

(*d*) By the corresponding respiratory intensity, — the amount of oxygen absorbed after the quotient of fermentation appears is much less than before, while the quantity of oxygen absorbed after the quotient of acids appears is much greater than before.

(*e*) By the change which takes place when sections are made, — sectioning slightly diminishes the quotient of respiration and scarcely increases the corresponding respiratory intensity, while it considerably raises the quotient of acids and at the same time greatly increases the respiratory intensity.

Since the acids and tannins disappear rapidly at high temperatures, the ripening of sweet fleshy fruits containing acids (apples, grapes, oranges) or tannins (persimmons) or a mixture of acids and tannins (sorbs, medlars, pears) may be hastened by exposure to warmth. The ripening of fruits containing much acid and not subject to fermentation due to asphyxiation (certain apples, grapes, cherries, oranges, etc.) may be retarded by exposing them to temperatures approaching 0° C., since at low temperatures the acids are not oxidized. On the contrary, fruits containing tannin, and which present at the close of ripening a quotient of fermentation (sorbs, medlars, persimmons, bananas), cannot be preserved much longer at low temperatures than at high ones, since the tannin is oxydized as well at one temperature as at another, and immediately after its disappearance the pectose is transformed into pectin, oxygen is excluded, the period of fermentation sets in, and the fruit

softens. Finally, the need of a high temperature for the combustion of tartaric and citric acid and the possibility of the oxidation of malic acid at lower temperatures explains why apples, sorbs, medlars, and other fruits which contain malic acid are able to ripen in cold climates, while grapes and oranges require warmer climates. It also explains why fruits containing malic acid ripen in cool places after picking, while grapes, and especially oranges and other citrus fruits, do so only imperfectly. However, by raising the temperature, fruits containing citric and tartaric acid will ripen in the fruit house.

E. F. S.

Ferns of Nicaragua. — An attractive-looking piece of work bearing the above title forms the second paper in the *Bulletin from the Laboratories of the State University of Iowa*, vol. iv, No. 2, pp. 116–224. The author of the paper is the well-known zoologist Mr. B. Shimek, who collected these plants on the island of Ometépe in Lake Nicaragua and in a narrow strip of country along the San Juan River. Over 120 species of ferns were collected in this small area in less than four months devoted to general botanical work. Judging from Mr. Shimek's statements, the fern flora of Nicaragua appears to be even richer in species than that of New Zealand, but the individuals are not so numerous. Only about one-fifth of the species listed by Mr. Shimek occur in Fournier's list of 121 Nicaragua ferns, and only about two-fifths in Mr. Helmsley's list of 135 species. Much of the territory is still only very imperfectly explored. The paper contains some interesting general remarks on tropical ferns, a key to the orders and families, and a list of the species collected, including helpful notes and a citation of books in which descriptions may be found. Several species are transposed into other genera, and one new species is described, — *Polypodium macbridense*. The text is supplemented by twenty well-executed half-tone plates.

E. F. S.

Pharmaceutical Archives. — With the beginning of the current year, owing to the large amount of original matter offered for the columns of the *Pharmaceutical Review*, the journal has been relieved of much of this matter by the starting under the same management of a second journal under the heading given above. The first number contains articles on the comparative structure of the leaves of *Datura stramonium*, *Atropa belladonna*, and *Hyoscyamus niger*, the popular names of Brazilian plants and their products, a chemical bibliography of morphine, and a study of the structure of the twigs

of *Fraxinus americana.* Though primarily intended for the pharmacist, these articles are of no little value to the botanist, and Dr. Kremers is to be congratulated on the promising outlook for his new journal. T.

Indiana Botany. — Several articles in the *Proceedings of the Indiana Academy of Science* for 1896, recently issued, are of interest to botanists; namely, "Notes on the Flora of Lake Cicott and Lake Maxinkuckee," by Robert Hessler; "Notes on Some Phanerogams New or Rare to the State," by W. S. Blatchley; "Periodicity of Root Pressure," by M. B. Thomas; "Notes on the Flora of the Lake Region of Northeastern Indiana," by W. W. Chipman; "Additions to the Published Lists of Indiana Cryptogams," by L. M. Underwood; "The Bacteriological Flora of the Air in Stables," by A. W. Bitting and C. E. Davis; "An Experimental Study on the Pathogenic Properties of Common Yeasts"; "Exceptional Growth of a Wild Rose," by Stanley Coulter; "A Revision of the Genus Plantago occurring within the United States," by Alida M. Cunningham, in which *P. minima* and *P. rubra* are described as new; "The Effect of Drought upon Certain Plants," by Clara A. Cunningham; "Additions to the Cryptogamic Flora of Indiana," by J. C. Arthur; "The Uredineæ of Tippecanoe County," by Lillian Snyder; and "The Occurrence of the Russian Thistle in Wabash County," by A. R. Ulrey. As might be expected, the papers are of very unequal value, and while those of local interest are useful, if somewhat fragmentary, the one monograph is scarcely likely to add materially to a knowledge of the group it deals with.

Sugar Cane. — The Bureau of Agriculture and Immigration of Louisiana has recently issued the first volume of a treatise on the history, botany, and agriculture of sugar cane and the chemistry and manufacture of its juices into sugar and other products, by Prof. W. C. Stubbs, Director of the Audubon Park Experiment Station at New Orleans. One chapter is devoted to the botanical relations of the plant, one to its anatomy and physiology, one to its modes of reproduction, and one to bacteriological notes on red cane. The remainder of the volume is historical and agricultural.

Digestion in Pitcher Plants. — It has been variously claimed that the digestion of proteides in the pitchers of Nepenthes is due to a digestive ferment secreted by them and to the action of bacteria growing in their secretion. Professor Vines, in the *Annals of Botany*

for December, 1897, gives additional corroboration of the former claim, since he shows that the secretion digests fibrin in the presence of one per cent. hydrocyanic acid, and that its enzyme retains its digestive activity when kept for several weeks in pure glycerine. His studies do not reach to the secretion of the necessary acid, which, in one species at least, is present in the liquid of unopened pitchers, and therefore is not the result of stimulation by the presence of foreign bodies.

Primitive Angiosperms.— From a morphological study of Naias and Zannichellia,[1] Professor Campbell shows that both anthers and ovules are axial structures, approaching, as he believes, more closely to the sporangia of Pteridophytes than do those of any other angiosperm, and he seems inclined to look upon these genera as standing nearer to the diverging point of Isoetaceæ and monocotyledons than do most representatives of the latter group.

New Species of Pectis. — Mr. M. L. Fernald, of the Gray Herbarium, contributes to the knowledge of Mexican plants by publishing in vol. xxiii, no. 5, of the *Proceedings of the American Academy of Arts and Sciences* a paper on some rare and undescribed plants collected at Acapulco by Dr. Edward Palmer in 1894, and a systematic study of the genus Pectis, including species of the United States as well as Mexico. Of this genus, *P. Lessingii*, *P. prostrata*, var. *cylindrica*, and var. *urceolata*, *P. sinalœnsis*, *P. depressa*, *P. capillaris*, var. *paucicapitata*, *P. filipes*, var. *subnuda*, *P. Pringlei*, *P. Rosei*, *P. elongata*, var. *Schottii*, *P. ambigua*, and *P. linifolia*, var. *marginalis* are described as new.

Botanical Notes. — Botanists will be interested in knowing that the herbarium and notes of the late M. S. Bebb, a collection invaluable for any systematic study of North American willows, have been purchased by the Field Columbian Museum of Chicago.

An article on "The North American Genus Sarracenia," illustrated by a reproduction of a photograph of *S. Chelsoni* (*S. rubra* × *purpurea*), is to be found in *Gartenwelt*, of Berlin, of Dec. 26, 1897.

Students of European botany, who have found difficulty in resigning themselves to the use of one name for the terra-cotta-flowered and blue-flowered forms of the poor man's weather-glass, which they

[1] D. H. Campbell, Contributions to Biology from the Hopkins Seaside Laboratory of the Leland Stanford Junior University. XI, A Morphological Study of Naias and Zannichellia. Reprinted from *Proceedings of the California Academy of Sciences*, 3d ser., Bot., vol. i. San Francisco, Cal., 1897. 61 pp., 5 pl.

have found almost side by side in various places, will appreciate a critical article on the annual species of Anagallis of Europe, which M. Clos publishes in No. 7 of the *Bulletin de la Société Botanique de France* for 1897.

A note by M. Franchet, in No. 7 of the *Bulletin de la Société Botanique de France* for 1897, shows that, though certain reduced forms of *B. lunaria* have been mistaken for it, *Botrychium simplex* really occurs in France.

Another application of anatomical characters to the delimitation of species has been made by Gillot and Carmentier, who show, in No. 7 of the *Bulletin de la Société Botanique de France* for 1897 that *Rumex palustris* is a hybrid of *R. maritimus* and *R. conglomeratus.*

In a paper on "The Spruces of the Adirondacks," read before the Albany Institute in November, 1897, Professor Peck states that, though until recently only two species of Picea were credited to the Adirondack region, there is now good evidence of the presence there of four species: *P. canadensis*, the white spruce, *P. mariana*, the black spruce, *P. rubra*, the red spruce, with a dwarf variety, *P. rubra pusilla*, and what is held to be a new species, the swamp spruce, *P. brevifolia*, with a dwarf variety, *P. brevifolia semiprostrata.*

That the active use of insecticides and fungicides, promoted by the publication of "Spray Calendars" and the like by our Agricultural Experiment Stations, is being watched with interest in England, is shown by the publication in the December number of the *Journal of the Royal Horticultural Society* of a rather extended paper by S. C. Lamb on "The Treatment of Insects and Fungi in the United States."

To cultivators of hothouse plants an article on the genus Nepenthes, by H. J. Veitch, published in the December number of the *Journal of the Royal Horticultural Society*, cannot fail to prove of interest. In it are given a historical account of the introduction of these Old World pitcher plants into cultivation, and a number of ecological and cultural observations. Several species are figured, some of them in the early stages of development.

That the botanists of far-away New Zealand are active is shown by the *Transactions and Proceedings of the New Zealand Institute* for 1896, recently received, which contains no less than twenty-one botanical articles, among them several of considerable ecological interest.

No. 230 of the *Journal of the Linnæan Society, Botany*, is given up to the completion of a paper by Sir John Lubbock on buds and

stipules, in which it is shown that the protective scales of winter buds may be either pedestals of last year's leaves, modified bases of leaves, leaf blades, modified leaves, stipules, connate pairs of stipules belonging to the same leaf, or connate pairs of stipules belonging to different leaves.

In the issue of *Science* of Dec. 17, 1897, Dr. J. W. Harshberger published an article on "The Native Dahlias of Mexico," in which, especially, the conditions under which these popular garden plants naturally occur and their natural color variation are made the subject of inquiry.

The mucilage cells of Opuntia have been made the subject of a recent study by Longo,[1] who states that they occur distributed through the fundamental parenchyma of all members of the plant, that their mucilage does not result from a transformation of the cell wall, but is a direct product of their protoplasm, and that their function is that of a water tissue. The same author has also[2] studied certain crystal and mucilage cells which are found in the branches and fruit of Platopuntias, though absent from the Cylindropuntias.

To students of the African flora the series of papers on Italian collections of Harar and Somali plants being published by the staff of the Berlin Garden in current numbers of the *Annuario* of the Botanical Institute of Rome should be of interest. A number of new species are described.

[1] *Annuario del R. Ist. Bot. di Roma*, **7**: pp. 44–57, pl. 2.
[2] *Loc. cit.*, pp. 79–83, pl. 8.

SCIENTIFIC NEWS.

THE circulars of the Marine Biological Laboratory at Woods Holl have been issued. The elementary zoological course will be under the direction of Prof. James I. Peck, assisted by Messrs. Dalgren, Greene, Lefevre, Murbach, Packard, and White. The botanical work will be directed by Prof. Bradley M. Davis, with the assistance of Messrs. Moore, Caldwell, Harper, Fairchild, Webber, Swingle, and Mrs. Esten. Physiological studies will be directed by Prof. Jacques Loeb, assisted by Messrs. Norman and Lyon. The work in elementary embryology will be in charge of Messrs. Lillie, Strong, Crampton, Treadwell, and Miss Clapp, while the zoological investigation will be conducted by Professors Ayers, Bumpus, Conklin, McMurrich, Metcalf, Morgan, and Morrill. New features are seminars in embryology and neurology, conducted by Drs. Conklin, Morrill, and Strong, and a course of instruction in methods of illustration by Dr. Arnold Graaf. The laboratory intends to incorporate in its tenth report a historical sketch of the institution. The session for 1898 extends from June 29 to August 10. The prices charged are the same as in previous years.

It has been proposed to rebuild the museum at South Kensington, London, and Parliament will be asked to grant an appropriation of £3,000,000 for the purpose.

The New York Public Library has received $10,000 from Mr. Jacob H. Schiff for the purchase of scientific works.

Mr. George Sharman has resigned his position as paleontologist of the Geological Survey of Great Britain, and Mr. George K. Cherrie that of assistant director of ornithology in the Field Columbian Museum of Chicago.

The Museum of Comparative Zoology has recently acquired a fossil ostrich egg from the neighborhood of Pekin, China. It has almost exactly the same dimensions as the *Struthiolithus chersonensis* of Brandt.

For some time *Science* has been publishing a series of articles by different persons dealing with the question of the age of the implements found in the Trenton gravels. The layman in such matters is left in doubt between the various conflicting claims, but with a general feeling that these relics cannot have the great age sometimes attributed to them.

Prof. E. Ray Lankester has been elected Fullerian Professor of Physiology in the Royal Institution of Great Britain. He is to give a course of seven lectures on the simplest living things. This appointment does not interfere with his position in the University of Oxford.

The Geological Society of London has awarded the Wollaston medal to Prof. F. Zirkel, the Murchison medal to T. F. Jamieson, and the Lyell medal to Dr. W. Waagen.

In the editorial department of this journal for February a plea was made for the exercise of common sense in questions of scientific nomenclature. In *Science* for January 21 Dr. Theodore N. Gill has a case in point. In 1852 Dana recognized a genus Arctus and took for his type the *Scyllarus arctus* of Fabricius. Now, since Arctus was the only species known to Fabricius, Dr. Gill proposes to overturn this work which has stood for nearly half a century, to refer Arctus back to the genus Scyllarus, and to refer those species which later students assigned to Scyllarus to a new genus Scyllarides. We doubt if almost "every zoologist" will admit the necessity for the change. Why not leave well enough alone? The proposed change merely introduces confusion where all was simplicity before.

Prof. Thomas Jeffrey Parker, of the University of Otago, New Zealand, died at Dunedin, Nov. 7, 1897. He was the son of the late William Kitchen Parker, and received his scientific training at the hands of his father and of Huxley. From 1872 to 1880 he was demonstrator of biology at the Royal College of Science, South Kensington. In that year (1880) he went to New Zealand, where he remained until his death. He was most widely known by his books, *Instruction in Zootomy* (1884) and *Lessons in Elementary Biology* (1891), but he had published numerous articles dealing chiefly with Vertebrata and Crustacea. Shortly before his death, in connection with Prof. W. A. Haswell, he had completed the manuscript of a text-book of zoology just published by the house of Macmillan.

The University of Chicago makes appropriations of $729,000 for the University year beginning July 1, 1898. Among the items we note the following: for the faculty of arts, literature, and science, $347,000; libraries, laboratories, and museums, $44,000; printing and publishing, $41,000. The total number of graduate students in the university is 324, of whom 122 are women.

At the meeting of the Yale Corporation held on the 13th inst. O. C. Marsh, professor of paleontology, formally presented to the University the valuable scientific collections belonging to him, now

deposited in the Peabody Museum. These collections, six in number, are in many respects the most extensive and valuable of any in this country, and have been brought together by Professor Marsh at great labor and expense during the last thirty years. The paleontological collections are well known, and were mainly secured by Professor Marsh during his explorations in the Rocky Mountains. They include most of the type specimens he has described in his various publications. The collection of vertebrate fossils is the most important and valuable of all, and includes, among many others, (1) the series of fossils illustrating the genealogy of the horse, as made out by Professor Marsh and accepted by Huxley, who used it as the basis of his New York lectures; (2) the birds with teeth, nearly two hundred individuals, .described in Professor Marsh's well-known monograph, "Odontornithes"; (3) the gigantic Dinocerata, several hundred in number, Eocene mammals described in his monograph on this group; (4) the Brontotheridæ, huge Miocene mammals, some two hundred in number; (5) Pterodactyles, or flying dragons, over six hundred in number; (6) the Mosasaurs, or cretaceous sea-serpents, represented by more than fifteen hundred individuals; (7) a large number of Dinosaurian reptiles, some of gigantic size. Besides, there are various other groups of mammals, birds, and reptiles, most of them including unique specimens. Additional collections comprise extensive series of fossil footprints, invertebrate fossils, recent osteology, American archæology and ethnology, and minerals. The main conditions of the gift, which is for the benefit of all departments of the university, are that the collection shall remain in a fireproof building, and under the control of Professor Marsh during his life, after that under the charge of the trustees of the Peabody Museum, and, finally, that type specimens shall not be removed from the museum building. From a scientific point of view, the value of the collections is beyond price, each one containing many specimens that can never be duplicated and already are of historical interest. Altogether, this is the most important gift to natural science that Yale has yet received.

Franz Kempe, of Stockholm, has endowed a chair of vegetable biology in the University of Upsala with $40,000 and has nominated Dr. A. N. Lundström of Ultuna as the first occupant.

Dr. Rodolfo Amando Philippi, on account of his age (ninety years), has resigned his position as Director of the National Museum in Santiago, Chile. His son, professor of natural history in the university there, has been appointed his successor.

Prof. Hans Molisch, of Prague, is spending a year in the botanical gardens at Buitenzoog.

Dr. Karl Futterer, of Carlsruhe, has gone on a geological expedition to Central Asia.

The University of Bonn has received the valuable anthropological collections of the late Mr. Schaafhausen.

The library of the late Prof. Carl Vogt has been purchased by the Senckenberg Society of Frankfurt am Main.

Some years ago the Boston Society of Natural History attempted to establish zoological gardens and aquaria in Boston, but from the first, as a result of impracticable plans, the project was doomed to failure. Recently the idea has taken another form, and the mayor of the city, Mr. Josiah Quincy, in his inaugural address, recommended that the city itself take up the work, which it was estimated would involve an expenditure of about $200,000.

The gypsy moth still makes demands upon the Massachusetts Legislature. The state has already expended considerably over half a million dollars in the attempt to exterminate the pest, and for the coming year the committee of the State Board of Agriculture having the work in charge ask for an appropriation of $200,000 for the work in 1898. That the insect can be kept in check cannot be denied, but that extermination of it can be accomplished does not seem so certain to us as it does to the committee. It is proposed by some to limit the appropriation to $75,000.

Recent Appointments: Dr. Abelous, professor of botany in the University of Toulouse, France. — Dr. Otto Finsch, director of the collection of ornithology in the Leyden Museum. — Dr. Hollermann, privat docent in botany in the University of Berlin. — Dr. Julius Istvánffy, professor of botany in the University of Klausenburg, Hungary. — W. P. Pycraft, temporary assistant in ornithology in the British Museum. — Mr. Francis Ramaley, of Minneapolis, assistant professor of botany in the University of Colorado at Boulder. — Dr. L. Rhumbler, privat docent in zoology in the University of Göttingen.

Recent Deaths: Charles Cornevin, professor of zoology and hygiene in the veterinary school at Lyons, France. — Dr. Mietschke, a German entomologist. — George H. Piper, geologist, of Ledbury, England. — Dr. F. Sintenis, German student of Diptera. — Prof. Ernst Ludwig Taschenberg, entomologist, of Halle, Jan. 20, 1898. He was born Jan. 10, 1818.

CORRESPONDENCE.

To the Editors of the *American Naturalist*:

I have recently had occasion to do some work which involved the comparison of genera in several groups of vertebrates, and in my studies I have made some discoveries which were rather surprising to me. For instance, I find our thrushes, in many works, distributed between two or three genera, our wood thrush being in the genus Turdus, the common robin in the genus Merula. The sole differences I find recorded between these two genera are best shown in the deadly parallel:

TURDUS.	MERULA.
Bill much widened at the base.	Bill little widened at the base.
Tarsi decidedly longer than middle toe and claw.	Tarsi little longer than middle toe and claw.
Spotted beneath.	Beneath mostly unicolor with streaked throat.
Of small stature and rather slender form.	Large, stout.

Again, I find our pestiferous English sparrow in the genus Passer, while the purple finch is in the genus Carpodacus. The distinctions between these two genera are:

PASSER.	CARPODACUS.
Bill without nasal ruff.	Nasal ruff little developed.
Culmen curved.	Culmen moderately curved.
Commissure little angulated.	Commissure decidedly angulated.
Gonys convex, ascending.	Gonys straight.
Wing five times the length of carpus.	Wing not quite five times the length of carpus.
Wing pointed by first three quills.	Wing pointed by first three or four quills.
Tail shorter than wings.	Tail much shorter than wings.
Tail nearly even.	Tail forked.
Tarsus about equal to middle toe and claw.	Tarsus shorter than middle toe and claw.
Lateral toes of equal length.	Lateral toes subequal.
Claws of lateral toes not reaching to base of middle claw.	Claws of lateral toes reaching the base of middle claw.

Turning to the higher groups, I find families distinguished by characters of hardly more importance, thus:

TURDIDÆ.	SYLVIIDÆ.
First primary short, strictly spurious.	First primary short, sometimes strictly spurious.
Bill rather long, usually notched at the tip.	Bill slender, notched, and decurved at the tip.
Tarsi always booted.	Tarsi usually booted.
Tail shorter than wings.	Wings longer or not longer than tail.
Tarsus little, if any, longer than middle toe and claw.	Tarsus longer than middle toe and claw.
Basal joint of middle toe attached its whole length externally, halfway internally to adjacent toes.	Inner toe free; outer toe united to middle toe for not half its length.
Size medium.	Size small.

Now, with this preamble, my question is this: Are these genera and families equivalent to genera and families in other groups? To me it would seem that the distinctions between Merula and Turdus and between Passer and Carpodacus are not equivalent to those used to distinguish even subgenera in other groups of vertebrates or invertebrates; while the family characters quoted would be of not more than generic rank in, say, reptiles or fishes. However, this is merely the opinion of one not an ornithologist, and I would like the views of other naturalists upon the subject. Cannot you induce students interested in the systematic study of vertebrates — ornithologists, mammalogists, herpetologists, and ichthyologists — to express their views upon the matter? I am sure that a discussion of the questions involved would interest many readers of the *American Naturalist*.

ZOOLOGIST.

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THE SARCOSTYLES OF THE PLUMULARIDÆ.[1]

C. C. NUTTING.

There is no little confusion regarding the nomenclature involved in morphological discussions concerning the Hydroida, and nowhere is this fact more evident than in connection with certain interesting structures found in the Plumularidæ and variously called nematophores, protoplasmic processes, defensive zooids, sarcodal processes, Machopolyps, "Wehrthiere," and Nesselpolypen by the numerous writers who have investigated them. The first mention that I have been able to find of these structures is by Busk in Hunterian Lectures (MSS.), London, 1857, who called them "Nematophores," — a name subsequently used by various writers. Hincks afterward applied the name "sarcotheca" to the chitinous receptacle, and "sarcostyle" to the sarcodal contents, or rather defensive persons, inclosed within it. Without further discussion on this point, I will state that I use the word nematophore for the receptacle without necessary reference to its contents, and sarcostyle for the organ or person within, and it is to the latter that I invite attention at present.

[1] Read before section F at the Detroit meeting of the American Association for the Advancement of Science.

The hydroids have been carefully studied by so few zoologists that it may not be amiss to define the sarcostyle more explicitly before discussing it. A careful investigation of any plumularian hydroid will disclose the fact that beside the hydrothecæ containing the hydroid polyps or hydranths, there are numerous usually minute chitinous cups containing an exceedingly interesting structure, which in life is characterized by amazing extensibility. Allman in 1864 described it as "a soft granular mass which could send forth very extensible processes capable of being greatly protruded, and then so completely retracted as to apparently disappear. These processes have the power of sending forth pseudopodia, as does the amœba, and act in many respects as do certain rhizopods." This author considered that these processes were composed of protoplasm, pure and simple.

When, however, the more refined and modern histological technique was applied by Hamann to the investigation of the sarcostyles, it was discovered that they were much more complicated structures than was at first supposed; that they were made up of several histological elements; namely, an ectodermal layer surrounding an axial portion composed of endodermal cells, the ectoderm and endoderm being separated by a structureless membrane or "Stutzlamelle." The distal part of the sarcostyle contains nematocysts or nettling cells. This author (Hamann)[1] concluded that the enormous extensibility of the sarcostyle was due to muscle fibrillæ, and regards the entire sarcostyle as a degraded person or hydroid polyp in which the mouth and body cavity have been obliterated.

In the same year, 1882, C. de Merejkowsky[2] announced that the histological elements were ectoderm and endoderm with a dividing membrane, and that the motile part was composed of ectoderm alone, the ectodermal cells being ***immersed in a contractile structureless protoplasm.*** To this latter substance he attributed the enormous extensibility of the sarcostyle and the pseudopodia-like processes originally described by

[1] Der Organismus der Hydroidpolypen. *Jenaische Zeitsch. f. Naturw.*, Bd. xv, pp. 17, 18, 65.

[2] *Arch. de Zool. Exp. et Gen.*, vol. x, pp. 583–610.

Allman. This author regards the sarcostyles as degenerate individuals of the hydroid stock, serving the purpose of defensive organs and possibly also as aid in the nourishment of the colony.

Weismann, in his *Die Enstehung der Sexualzellen bei den Hydromedusen*, denies the presence of the interstitial protoplasm in the ectodermal portion and contends that the pseudopodia are from the ectoderm cells themselves.

In the same year, 1883, von Lendenfeld[1] made a very elaborate study of the sarcostyles. In addition to the ectoderm, endoderm, and "Stutzlamelle" already mentioned, he found a differentiated ectodermal muscle layer, in which are large ganglion cells in Plumularia. In certain species of Aglaophenia and Plumularia he found sarcostyles furnished with adhesive cells similar to those found in ctenophores, but differing from them in not having a spirally rolled thread.

Dr. Carl F. Jickeli[2] agrees with most of the other writers concerning the histology of these structures, but has a unique idea of their homology. He thinks that the sarcostyles are homologous with the capitate tentacles of many species of hydroid polyps. I believe that he has no supporters in this view.

No other investigations of sufficient importance to discuss in this connection have been made so far as I know, with the exception of my own work in 1895 at Plymouth, England,[3] and at Naples, where I made careful studies of these structures in the living plumularians and by means of serial sections.

The histology of the sarcostyles, as held by most of the above writers, shows an outer layer of ectoderm and an inner layer of endoderm, these two layers being separated by an apparently structureless membrane called by the German writers the "Stutzlamelle." The endodermal layer appears to be a solid core in stained and sectioned preparations, and is so described by most writers. Under favorable conditions living

[1] Ueber Wehrpolypen und Nesselzellen. *Zeit. f. wiss. Zool.*, Bd. xxxviii, pp. 355-371. [2] *Morphol. Jahrb.*, Bd. viii, pp. 580-680.

[3] See C. C. Nutting, Notes on Plymouth Hydroids. *Journ. Marine Biol Assoc.*, February, 1896, p. 153.

specimens may be examined under a high power, and by a proper management of light the cell boundaries, muscle, and indeed almost every histological detail may be distinctly seen and the movements followed. It was while making such examinations of living sarcostyles at Naples in 1895 that I found an unexpected proof that the axis of the sarcostyle is not a solid rod, but a delicate collapsible tube, the cavity of which is strictly homologous with the body cavity of the hydranth. While studying a living sarcostyle under a $\frac{1}{12}$ oil-immersion lens, the endodermal axis, as it is called, was very sharply defined, being separated from the ectodermal layer by the "Stutzlamelle." Much to my surprise, I saw an amœboid cell pass quickly along the exact center of the axis. The cell was largely composed of highly refractive granules and exhibited very active amœboid movements, sending forth well-marked pseudopodia and constantly changing form. This mysterious cell appeared to be engaged in traveling back and forth between the distal and proximal end of the axial cavity of the sarcostyle. Its progress was unimpeded and completely demonstrated to my mind the presence of an axial cavity in the sarcostyle. After having once seen this cell, I looked for them in other sarcostyles and found them in nearly every one examined. The species under observation was *Aglaophenia helleri.* I afterward found similar cells in the endoderm of various parts of the plumularian colony, particularly in the stem. In such localities, however, they did not move from place to place, but nevertheless sent forth numerous pseudopodia and exhibited amœboid change of form.

This demonstration of an axial cavity in the sarcostyle is of considerable interest, in view of the fact that it furnishes the last and much-desired link in the evidence needed to demonstrate the homology of the sarcostyle. It can no longer be doubted, it seems to me, that the sarcostyle is the homologue of the hydranth; that it is, in fact, a true "person" of the hydroid colony, being composed of ectoderm, "Stutzlamelle," endoderm, and body cavity. It lacks only tentacles to make it a hydranth, but we know that certain hydroids, *e.g.*, Protohydra, have undoubted hydranths without tentacles.

Curiously enough, one of the earliest observers of nematophores published in 1863 a figure of a sarcostyle which was represented as having a body cavity. The author referred to is Semper, and the figure is found in the *Zeitschrift für wiss. Zoologie*, Bd. xiii, Pl. XXXVIII, Fig. 4 *a*.

The conclusion that sarcostyles are morphological persons of the colony is borne out by almost every known fact concerning them. Embryological investigation shows that they are formed in almost exactly the same manner as the hydranths, and that they make their appearance as early as the latter and often earlier. It is possible, moreover, to point out a series of forms leading from the so-called "fighting zooids" of Hydractinia to the typical nematophores of the Plumularidæ. In the genus Ophiodes we find organs or persons almost exactly intermediate between the Hydractinia and true sarcostyles. Prof. Baldwin Spencer has lately described a new family of Hydroida, called the Hydroceratenidæ, evidently closely allied to the Plumularidæ, with numerous fighting persons which are histologically almost identical with true nematophores; the extreme extensibility, however, of the latter has not as yet been observed in the former. There appears also to be a curious cross relation between the dactylozooids of the Millipora and the sarcostyles, if such they be, of the Hydroceratenidæ.

Among the many perplexing questions in this connection is the one raised by Professor Allman, who very strongly urges the relationship between the nematophores and the denticles of the graptolites. His argument would lead to a belief that the ancestors of the Plumularidæ may be the graptolites; that the nematophores of the former are the homologues of the denticles of the latter; that we have in the sarcostyle the original type of the hydranth; and that the present hydranth is really a very highly specialized sarcostyle.

As before indicated, the sarcostyles often precede the hydranths in the development of the colony, and would thus appear to be an older structure in phylogeny.

I was unable to confirm Merejkowsky's statement that the extensible part of the sarcostyle was composed of ectodermal cells immersed in free protoplasm. Indeed, it appears that no

other author has been able to demonstrate this certainly unique and surprising arrangement. Neither could I find the muscle bundles and ganglion cells of von Lendenfeld, although this purely negative evidence should not be allowed to have much weight. The adhesive cells were found in several species of Aglaophenia, and observed in action; the observations confirm very decidedly the description given by their original describer, von Lendenfeld.

There has been considerable discussion concerning the probable use of the sarcostyles. My own observations on the living organisms would indicate that they serve several distinct functions.

1st. *Defense.* In many cases, especially in the genera Aglaophenia, Lytocarpus, and Cladocarpus, the distal part of the sarcostyle contains a battery of very large and formidable nematocysts or stinging cells. The threads of these cells are projected all together when a large or dangerous enemy approaches too near the adjacent hydranth. It is probable that the cnidocils of these nematocysts must be touched before the battery is discharged. Some species of Lytocarpus have such effective batteries that their sting is severely felt through the human cuticle, a very unusual thing among the Hydroida. The nematocysts themselves do not leave the nematophores when their threads are projected.

2d. *Prehension of food.* This is effected by the adhesive cells, which are situated on the extensible part of the sarcostyles of many species. Von Lendenfeld gives an excellent description of the capture of small crustacean zoæa. From his account it appears that the prey is first paralyzed by the nematocysts in the tentacles of the hydranths, and then secured by the adhesive parts of the adjacent sarcostyles which stick firmly to the smooth chitinous covering of the crustacean. After this attachment is formed, the contraction of the sarcostyle brings the victim again within the reach of the tentacles, which convey it to the mouth of the hydranth.

3d. *The removal of refuse or decomposing organic matter.* This function of the sarcostyles has been suggested by several

writers. I have on many occasions noted that the sarcostyles are very active after certain parts of the colony have been mutilated or where the hydranths are undergoing disintegration. While studying *Plumularia pinnata* at Plymouth I saw astonishing exhibitions of activity on the part of the sarcostyles in the vicinity of mutilated gonangia. Their extensibility was incredible and apparently without limit. They would climb over the top of the gonangia and scour the inside, they would wind round and round the stem and branches in a perfect maze of apparently protoplasmic threads, and yet be able to unsnarl themselves with the greatest ease and afterward disappear entirely. Dead hydranths seemed particularly attractive to them, and it appeared as if they actually devoured or in some way absorbed the organic matter of the disintegrating polyps, so that not a trace remained within the hydrothecæ in a very short time after the sarcostyles attacked them.

4th. *Holding together adjacent corbula leaves until their edges unite.* This is a novel use of the sarcostyle, discovered by myself while working out the embryology of the corbula, or fruit receptacle, of *Aglaophenia pluma* at Plymouth. The corbula is a pod-shaped structure made up of a number of ribs or leaves, which are separated first, but afterward coalesce to form the mature corbula. Along the edges of these leaves are rows of nematophores.

While examining a young corbula of a living colony, I noticed that the sarcostyles along the edges of the leaves were exceedingly active and that they were stretching across from one leaf to the next, to which they adhered by their adhesive ends. "It appeared as if these sarcostyles served as a temporary attachment to hold the edges of the two leaves together, while the edges themselves were connected by trabeculæ of cœnosarc which rapidly formed a stronger and permanent connection. The perisarc of the edges of the leaves seemed exceedingly thin and in places appeared to be wanting. A contact having been established between the adjacent leaves, the permanent attachment was soon formed and the cœlomic cavities of the leaves established connections at these points.

A little later currents of water bearing granules were seen to flow in active streams from one leaf to the other." [1]

In this case it appeared as if the sarcostyles served to hold the edges of the leaves together while the permanent connection was being established, after which the sarcostyles loosened their hold and retracted into their respective nematophores.

[1] C. C. Nutting, Notes on Plymouth Hydroids. *Journ. Marine Biol. Assoc.*, February, 1896, p. 153.

THE WINGS OF INSECTS.

J. H. COMSTOCK AND J. G. NEEDHAM.

CHAPTER III.

The Specialization of Wings by Reduction.

I. INTRODUCTION.

THE recognition of certain features of the venation of the wings of insects which occur in the more generalized forms of a large proportion of the orders of this class has enabled us to present a hypothetical type to which the wings of all orders may be referred. A detailed discussion of the features of this

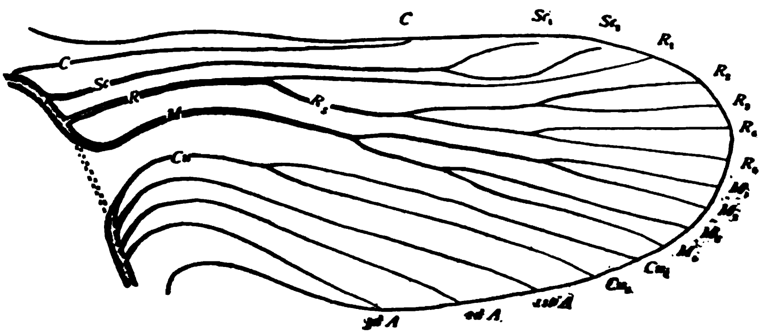

FIG. 5. — Hypothetical type.

type has already been given; the figure representing it is repeated here (Fig. 5) in order that it may be easily compared with figures of actual wings. It represents the supposed arrangement of the tracheæ in a wing of the nymph of the primitive winged insect. By omitting the basal part, the figure will also serve to show the number and arrangement of the longitudinal wing-veins of the adult.

It will be seen at a glance that this hypothetical type differs from the great majority of living insects in the possession of a larger number of wing-veins than is characteristic of them; it also differs, and in a more striking degree, from most of the

insects of the Linnean order Neuroptera in having a much smaller number of wing-veins than is possessed by them.

These differences indicate two different methods of specialization by which this primitive type has been modified: the one, specialization by reduction; the other, specialization by addition.

We postpone any farther reference to the latter method of specialization and confine our attention in this place to a study of some of those forms in which a tendency to modify the primitive type by a reduction in the number of wing-veins is evident.

A reduction in the number of wing-veins takes place in two ways: first, by atrophy of veins; second, by the coalescence of two or more adjacent veins.

The first method is illustrated in most of the orders where a reduction in the number of wing-veins has taken place by the atrophy, more or less complete, of one or more of the anal veins; this is correlated with a reduction in the extent of the anal area. This method is also illustrated in certain cases where there is no apparent reduction of the area of the wing from which the vein has disappeared. The most familiar illustrations of this occur in the Lepidoptera. In this order, as is well known, the main stem of the media disappears in many families; and in the geometrid moths of the family Eunomidæ, the second branch of this vein is also lost.

The second method of reduction — that is, by coalescence — takes place in all of the orders in which the number of wing-veins is less than in the typical wing. This also takes place in two ways: first, the point at which two veins separate occurs nearer and nearer the margin of the wing, until finally, when the margin is reached, a single vein remains where there were two before; second, the tips of two veins may approach each other on the margin of the wing until they unite, and then the coalescence proceeds towards the base of the wing. The former is a coalescence extending outward; the latter, a coalescence extending inward. Examples of the former are common in all of the orders discussed in this chapter; illustrations of the latter are most easily observed in the Diptera.

The typical arrangement of the wing-veins is often modified, also, by an anastomosis of two veins; that is, two veins will come together at some point more or less remote from their extremities and merge into one for a greater or less distance, while their extremities remain separate. This is illustrated in Nemoura (Fig. 8), where veins Sc_2 and R_1 anastomose.

In the preceding chapter we suggested a nomenclature of the principal wing-veins and of their chief branches, which is applicable to all of the orders of winged insects. At that time nothing was said regarding the cross-veins; for it seems hardly

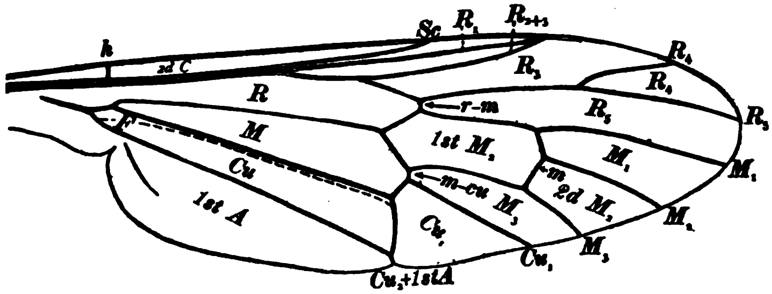

FIG. 6.—Wing of a Leptid, showing cross-veins and cells.

practicable to propose a nomenclature of these based on homologies which shall have an equally general application. This arises from the fact that in those orders where the number of wing-veins is greatly increased, the primitive cross-veins, if such exist, are in most cases indistinguishable from those that have been developed secondarily.

But when we examine the wings of those orders in which the tendency is towards a reduction in the number of wing-veins, we find that there are a few cross-veins which are so constant in their position and which occur in so many widely separated groups that they are evidently homologous. As the number of these is small, we propose to designate them by names, as follows:

The humeral cross-vein. This is a single cross-vein extending from the subcosta to the costa near the humeral angle of the wing (Fig. 6, *h*). This is the most constant of all of the cross-veins.

The radio-medial cross-vein. This is a cross-vein extending from radius to media, usually near the center of the wing, and is designated by the abbreviation *r–m*. When in its typical position, this cross-vein extends from R_{4+5} to M_{1+2}; this results in one end being opposite cell R_3 and the other end opposite cell 1st M_2. The cells are defined a little later.

The medio-cubital cross-vein. This is a cross-vein extending from media to cubitus, usually near the center of the wing. It is designated by the abbreviation *m–cu*. When in its typical position this cross-vein extends from a point near the base of M_{3+4} to a point near the base of Cu_1.

The medial cross-vein. This is a cross-vein extending from media-two (M_2) to media-three (M_3); this is designated by the abbreviation *m*. The presence or absence of this cross-vein is often a character of considerable taxonomic importance.

The arculus. In many insects there is what appears to be a cross-vein extending from radius to cubitus near the base of the wing. This has been termed the arculus by writers on the Odonata, and we propose to extend the use of the term to all orders in which there is a similar arrangement of the veins in this part of the wing.

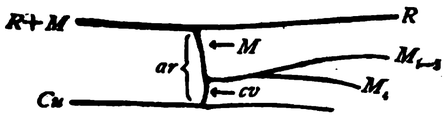

FIG. 7.—The arculus, diagrammatic.

The arculus is designated by the abbreviation *ar*. Usually when the arculus is present the media appears to arise from it. The fact is, the arculus is compound, being composed of a section of the media and a cross-vein. The structure of this part can be clearly seen in the Odonata (Fig. 7).

In descriptions of wings it is often desirable to refer to one or more of the cells. It is necessary, therefore, to have a nomenclature of the cells of the wing, as well as of the wing-veins. Certain of the cells have received special names; but as no effort has been made by those proposing them to trace the homologies of the cells beyond the limits of a single order, the names proposed are not available for our present purposes. A single example will serve to illustrate this. We find the term

discal cell used in descriptions of Lepidoptera, Diptera, Trichoptera, and Corrodentia (Psocidæ), but in no two of these orders is it applied to the same cell.

Having named the wing-veins, the simplest possible method of designating the cells of the wing is to apply to each the abbreviation of the name of the vein that forms its cephalic (front) margin. It should be borne in mind, however, that by modifications of the typical arrangement of the wing-veins, a vein that normally forms the cephalic margin of a cell may apparently bear a very different relation to it; and this must be taken into account if we are to apply the same term to homologous cells throughout the insect series.

The cells of the wing fall naturally into two groups: first, those on the basal part of the wing; and second, those nearer the distal end of the wing. The former are bounded by the principal veins; the latter, by the branches of the forked veins; a corresponding distinction is made in designating the cells. Thus the cell lying behind the main stem of radius and on the basal part of the wing is designated as cell R; while the cell lying behind radius-one is designated as cell R_1.

It should be remembered that the coalescence of two veins results in the obliteration of the cell that was between them. Thus when veins R_2 and R_3 coalesce, as in Leptis (Fig. 6), the cell lying behind vein R_{2+3} is cell R_3 and not cell R_{2+3}, cell R_2 having been obliterated.

When one of these principal cells is divided into two or more parts by one or more cross-veins, the parts may be numbered, beginning with the proximal one. Thus in Leptis (Fig. 6), cell M_2 is divided by the medial cross-vein into two parts, which are designated as 1st M_2 and 2d M_2, respectively.

The application of this system of naming the cells of the wing is an easy matter in those orders where the wings have few veins; but in those orders where many secondary veins are developed it is more difficult of application. In the latter case we have to do with *areas* of the wing rather than with separate cells. Thus, for example, it will be shown later that in certain Neuroptera the area R_2 is divided by several longitudinal veins, which are connected by many cross-veins, the area R_2 (which

is strictly homologous with cell R_2) being composed of a large number of secondary cells.

The wings of comparatively few insects present a flat surface; in most cases we find that the membrane is thrown into a series of folds or corrugations. This corrugating of the wing in some cases adds greatly to its strength. This is well shown by the wings of dragon flies; and in most orders the costal margin of the wing is strengthened by a fold between costa and radius, the *subcostal fold.* In other cases, the corrugations are the result of a folding of the wing when not in use; this is well shown in the anal area when this part is broadly expanded.

It rarely happens that there is occasion to refer to individual members of either of these classes of folds, except, perhaps, to the one that has just been designated as the subcostal fold. But there are three other furrows which it is necessary to designate, as we shall have frequent occasion to refer to them. These we term the anal furrow, the median furrow, and the nodal furrow, respectively. They may be defined as follows:

The anal furrow. This is a longitudinal furrow which is usually between the cubitus and the first anal vein (Fig. 6, *F*). It has been referred to by many writers, but the variableness of its position has not been pointed out.

The median furrow. This is a longitudinal furrow which is usually between radius and media. It is well marked in many of the Hemiptera, where it separates the embolium from the remainder of the corium; and in the Hymenoptera its course is marked by a series of weak spots (bullæ) in certain veins.

The nodal furrow. This is a transverse suture beginning at a point in the costal margin of the wing, corresponding to the nodus of the Odonata and extending towards the inner margin of the wing. It crosses a varying number of veins in different orders of insects.

The furrows of the wing are in no sense homologous or even analogous to veins. More than this, as will be shown repeatedly, the relative positions of the furrows and of the wing-veins are not constant; for it frequently happens that the course of a vein has been so modified that it crosses the line of a furrow and the relative positions of the two are thus reversed. If this fact

had been understood by Adolph we would have been spared his misleading theory of alternating concave and convex veins.[1]

II. The Venation of the Wings of Certain Plecoptera.

If we leave out of consideration the anal area, that portion of the wing traversed by the anal veins, we will find that in nearly every case each order of insects is characterized by either a reduction or a multiplication of the wing-veins; in certain orders the tendency is in one direction, while in others it is in the opposite. But either of these tendencies may be correlated with a similar tendency in the anal area or with the opposite one. In this chapter we purpose to point out the ways in which the primitive type of wing venation has been modified in representatives of several of the orders where a reduction in the number of wing-veins in the preanal area has taken place.

In the order Plecoptera, or stone flies, we find that, although in most genera the anal area of the hind wings has been expanded and the number of anal veins increased, in the preanal areas of both wings the number of wing-veins has been increased in certain genera and reduced in others; and we cannot say that either of these tendencies has yet attained the ascendency within this order.

This fact, taken in connection with the generalized condition of the basal attachments of the tracheæ of the wings, already pointed out, leads us to believe that the Plecoptera as a whole depart less widely from the primitive winged insect than do the living representatives of any other order.

In this place, we have to do only with those Plecoptera in which a reduction in the number of wing-veins in the preanal area of the wing has taken place. Of these, the genera Nemoura and Tæniopteryx are taken as examples. And we use, for the purposes of this study, wings of nymphs taken at a stage when the forming wing-veins appear as light-colored bands and the tracheæ, about which they are formed, as dark lines.

[1] G. Ernst Adolph, Ueber Insectenflügel. *Nova Acta der ksl. Leop.-Carol.-Deutschen Akademie der Naturforscher.*, Bd. xli, pp. 215–251. 1879.

In the nymph of Nemoura (Fig. 8) we have not observed a costal trachea. The subcosta is forked in the typical manner, and vein Sc_2 anastomoses with vein R_1. The radius is reduced, the radial sector being only two-branched; it is probable that this reduction came about by the coalescence outward of vein R_2 with R_3 and of vein R_4 with R_5. The media is reduced in a similar way. The cubitus is typical, but in the fore wing sev-

Sc_1 Sc_2

FIG. 8.—Wings of Nemoura, nymph.

eral cross-veins have been developed between its branches, and also between it and the media; the strengthening of this region of the fore wing is quite characteristic of the Plecoptera. The anal veins are typical in the fore wing, but in the hind wing the second and third anal veins are each forked.[1]

[1] There is a striking similarity between the anal areas of the Plecoptera and the Orthoptera; throughout both these orders the first anal vein remains simple in both wings, but the second and third anal veins are forked when this part of the wing is expanded.

The wings of a nymph of Tæniopteryx (Fig. 9) show a slightly different modification of the type. The costal trachea is well preserved. The subcosta is typical. The radial sector is reduced

FIG. 9. — Wings of Tæniopteryx, nymph.

even more than in Nemoura, the coalescence of veins R_{2+3} and R_{4+5} having extended to near the margin of the wing; the carrying of this process a little farther would reduce the radial

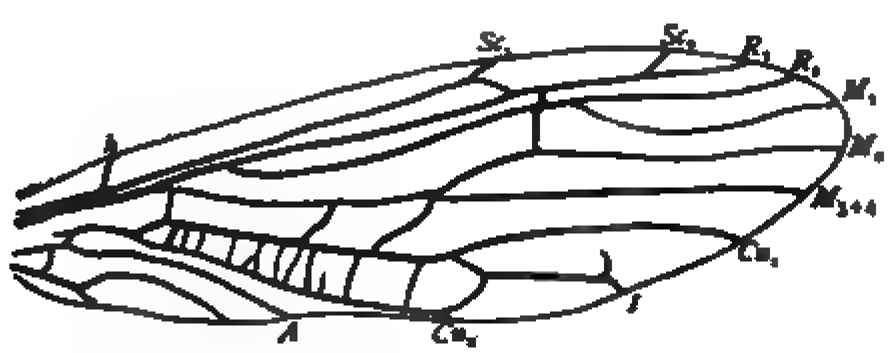

FIG. 10. — Wing of Tæniopteryx, adult

sector to an unbranched condition, which is what has happened in some species of this genus (Fig. 10). The media is three-branched in the fore wing and two-branched in the hind wing, but in the hind wing vein M_{3+4} coalesces with vein Cu_1. The

cubital trachea is typical in both wings, and the anal veins are quite similar to those of Nemoura.

There are two points of especial interest in the fore wing of this insect, both showing the importance of ontogenetic study in determining the homologies of wing-veins.

First, it is evident that, correlated with the great reduction of the radial sector, vein M_1 of the fore wing, which remains distinct from vein M_2 in this genus, has come to perform the function that is performed by vein R_{4+5} in Nemoura; and, as a result, it has assumed a similar position. So great is the similarity that one who studied only the wings of the adult Tæniopteryx would be certain to mistake vein M_1 for a branch of the radial sector. A glance at Fig. 10, which represents the fore wing of the adult of another species of this genus, will make this more evident. If the object in view were merely to number the wing-veins, it may be that a mistake of this kind would not be serious; but when the object is to determine the relationships of allied forms, such a mistake would surely lead one astray.

The second point illustrates specialization by addition, and it is anticipating somewhat to allude to it here. It will be observed that in Fig. 10 a vein which ends in the margin of the wing midway between veins Cu_1 and Cu_2 is labeled 1. This is what we shall define later as the first accessory cubital vein A reference to Fig. 9 will show that, although this vein has the same appearance as other longitudinal veins in the adult, it is not preceded by a trachea in the nymph, but, like the cross-veins, is formed secondarily. This is an illustration of the beginning of a process which is carried to a great extent in those insects that have wings with many wing-veins, and which will be described in more detail later.

It will be seen from these two illustrations that a study of the ontogeny of the wings opens a fruitful field to one engaged in a study of the genetic relationships of winged insects.

III. The Venation of the Wings of Psocus.

The determining of the homologies of the wing-veins in Psocus and allied genera is a problem that has sorely puzzled all who have worked upon it; and it has remained till now

unsolved, although it has been attacked by such writers as Hagen, McLachlan, and Kolbe.

But when it is approached by the ontogenetic method the difficulties vanish, and it is hardly necessary to do more for its solution than to refer to the accompanying figures representing

FIG. 11. — Psocus, fore wing of a nymph

three stages in the development of the fore wing of *Psocus venosus*. When one understands this wing, the working out of the homologies in the hind wing, which is more reduced, and in the wings of other genera is a comparatively simple matter.

Fig. 11 represents the wing of a nymph which was not yet full grown. The lettering of the figure indicates the homologies

FIG. 12 — Psocus, fore wing of a full-grown nymph.

of the tracheæ. The formation of the wing-veins has begun, but in most cases the outlines of these are vague. It will be observed that the wing is much smaller than the enveloping sheath.

Fig. 12 represents the wing of a full-grown nymph. Here the forming veins are much more definite in outline, and there is no difficulty in tracing the venation of the adult wing. The

costal trachea is preserved for only a short distance; the subcostal trachea extends far beyond the end of the forming vein; and for a considerable part of its course is within the light band that is to form the radius; the radial sector has been reduced to two branches; and only three branches of the media remain. The most striking features of this wing are the coalescence of media and cubitus, which is shown by the two tracheæ being

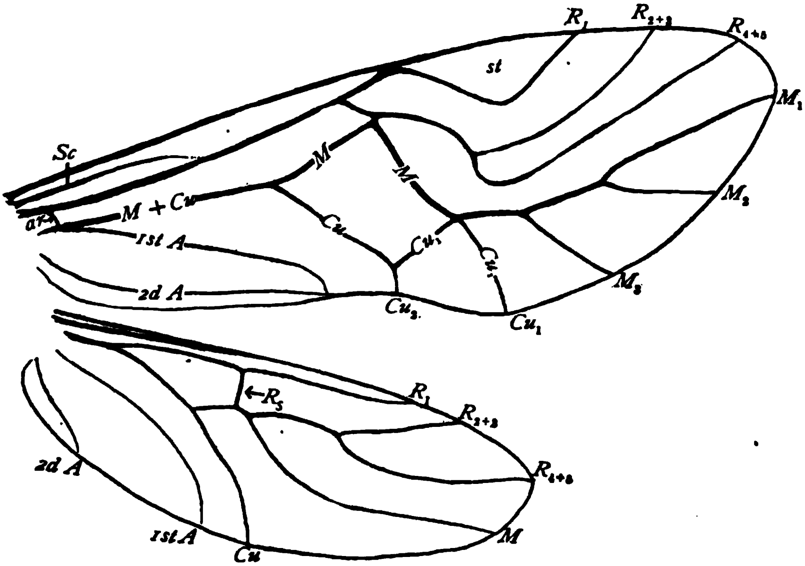

FIG. 13.— Psocus, wings of an adult.

closely parallel for a considerable distance within a single vein, and the zigzag course of media, which is easily determined by following the course of the medial trachea. Neither of these features is so well marked in the less mature wing. The first anal vein coalesces with cubitus at the base. The second anal vein has moved nearer to the margin of the wing. And the third anal trachea is no longer visible.

The wings of the adult are represented by Fig. 13. A remarkable feature of these wings is that, although they are braced in every direction, there is not a single cross-vein present, except an arculus which is formed of the base of the media; the bracing is accomplished by the zigzag courses of the prin-

cipal veins. This, however, is not true of all psocids. In some the bend in the media does not reach the radial sector, and the two are connected by a radio-medial cross-vein.

The margin of the adult wing is tubular throughout, there being what has been termed by writers on the Diptera an ambient vein. The costal and anal portions of this doubtless represent the costa and third anal veins, respectively, although the corresponding tracheæ are apparently lost. The distal portion of this ambient vein was preceded by the anastomosing tips of all of the veins, as is shown in the figures of the nymph wings. In the fore wing the tip of the subcosta coalesces with the radius; in the hind wing it coalesces with the costa. In the fore wing a large stigma is developed in an angle of vein R_1; and in both wings the anal furrow coincides with the first anal vein.

IV. The Venation of the Wings of a Cicada.

A study of the wings of Hemiptera reveals remarkable departures from the primitive type of wing venation. So great are these that, at first, one sees very little in common between the wings of a bug and those of insects of any other order. We were filled with delight, therefore, when we found within this order, preserved almost unchanged, what we had come to regard, from a study of other orders, as the primitive type of wing venation.

The conservative Hemiptera that retain most perfectly the fashions of ancient times, so far at least as concerns the venation of the wings, are the cicadas. But the slightness of the changes that have taken place is not obvious if one studies only the wings of the adult; for in this stage there is a massing of several veins along the costal margin of the wing, and the cross-veins have the same appearance as the branches of the primary veins.

In the wings of a young nymph, on the other hand, the tracheæ that precede the primary veins are not massed as they are later, and in the older nymph where the forming veins appear as pale bands the cross-veins contain no tracheæ.

In the wing of a nearly mature nymph (Fig. 14) the costal trachea extends nearly to the apex of the wing. The subcostal trachea is also prominent, but it is not forked. The radius is reduced to a three-branched condition. The media is typical. So, too, is the cubitus. The first anal trachea coalesces with the cubital trachea for a considerable distance. The second and third anal tracheæ are also united at the base, and the forming veins appear as pale bands.

The important departures from the primitive type are two: first, the coalescence of the first anal vein with the cubitus. This results in the anal furrow of the adult lying between the first and second anal veins; but these two are closely opposed

Fig. 14.— Cicada, fore wing, mature nymph.

in the fore wing of the adult, except for a short distance at the base of the wing, so that they appear as a single vein along the line of the furrow. The study of the wings of an adult which was killed at the moment of emergence from the nymph skin, and in which the tracheæ of the wings are distinctly visible within their corresponding wing-veins, has materially aided us in determining the relation of the anal furrow to the adjacent veins. It may be said in this connection that the coalescence of the first anal vein with the cubitus is a common occurrence in several of the orders.

A more striking departure from the primitive type is the reduction of the radius. For a long time we were unable to decide in what manner this had taken place. The usual mode of reduction of this vein is by the coalescence outward of the two branches of each half of the radial sector, leaving the

sector two-branched and the vein as a whole three-branched, as in Nemoura and in Psocus. But in these cases the intermediate branch of the radius arises from the posterior one of the three; in Cicada, on the other hand, the intermediate branch arises from the anterior one of the three (Fig. 14).

It was not till we succeeded in obtaining a very young nymph of Cicada that this question was definitely settled. In the fore wing of this nymph (Fig. 15) the radial trachea is five-branched; and the only departure from the typical mode of branching is

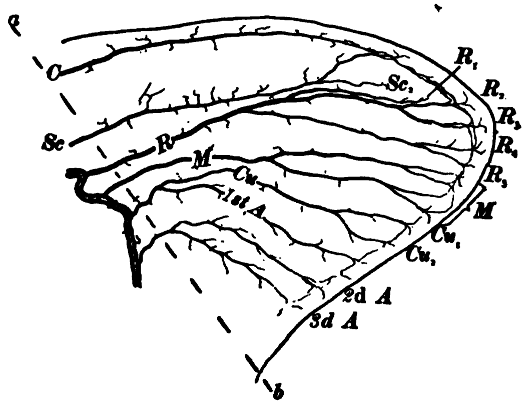

FIG. 15. — Cicada, fore wing, young nymph.

that the branch which corresponds to vein R_1 coalesces for a short distance with the one corresponding to the anterior half of the radial sector.

It will be observed that in this part of the wing the subcostal trachea closely approaches the radial. This crowding of the radial trachea by the subcostal is doubtless the explanation of the pushing outward of the point of separation of the trachea R_1 and of the complete atrophy of this trachea in the later stages of this insect, which results in the non-development of vein R_1.

We have discussed this matter at some length, not merely to show the close correspondence of the tracheation of the wing of the young nymph to our hypothetical type, but also to point out the course by which has been reached one of the most characteristic features of the venation of the wings of Hemiptera, that is, the complete absence of vein R_1.

From a study of the two nymph wings figured here, it is an easy matter to trace the homologies of the veins and cells of

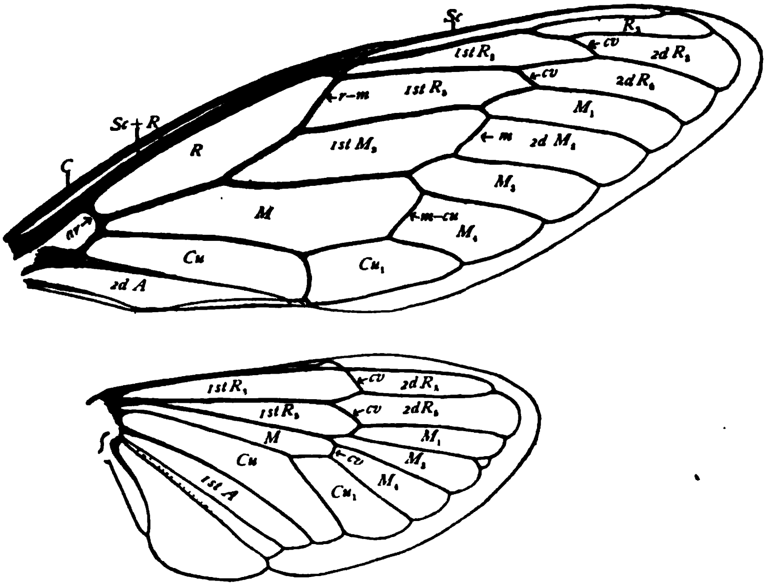

FIG. 16. — Cicada, wings of adult.

the fore wing of the adult; these are indicated by the lettering of this part in Fig. 16.[1] The more difficult points are eluci-

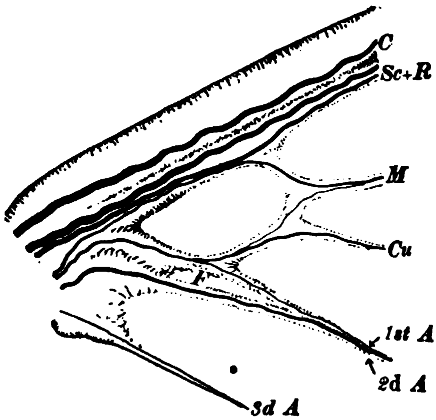

FIG. 17. — Cicada, base of fore wing.

[1] In those cases where the veins are not numbered, their homologies are indicated by the numbering of the cells behind them.

dated by Fig. 17, which represents the base of the fore wing of the adult, and Fig. 18, which represents the region of the nodal furrow of the same wing. These figures are based on a study of the recently emerged adult, already referred to. We

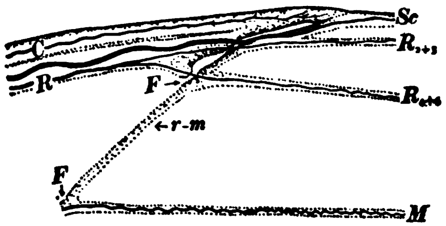

FIG. 18. — Cicada, nodal furrow of the fore wing.

wish to call attention especially to the coalescence of subcosta and radius from the base of the wing to a point near the nodal furrow, as this is a feature which occurs in a large proportion of the families of the Hemiptera.

The changes that have taken place in the hind wing of Cicada are much greater than those of the fore wing, and it would be

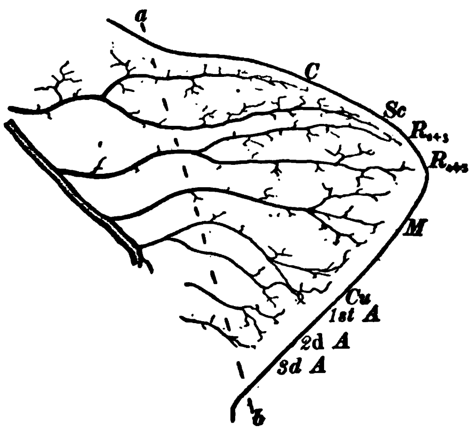

FIG. 19. — Cicada, hind wing, young nymph.

exceedingly difficult to understand them without the aid of ontogenetic study. But a careful comparison of the hind wing of a young nymph (Fig. 19) and the base of the hind wing of the recently emerged adult (Fig. 20) has cleared up the doubtful points.

In comparing the wings of nymphs, and especially of young nymphs, with those of the adult, it will be found that the growth of the basal part of the wing proceeds more rapidly at first than does that of the distal portion. This is shown by the fact that the branching of the branched tracheæ occurs much nearer the outer margin of the wing in the nymph than does the branching of the corresponding veins in the adult.

The difference is not so great, however, as appears at first sight, for only a part of what is represented in Fig. 19 corresponds to the wing of the adult. The dotted line *a–b* indicates

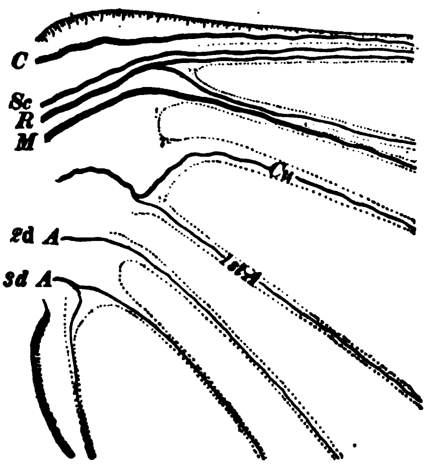

FIG. 20. — Cicada, base of hind wing.

approximately the line along which the hinge of the wing of the adult is formed. In Fig. 15, the line *a–b* represents the corresponding part in the fore wing.

By comparing Figs. 15 and 19 it will be observed that the forking of the radial trachea takes place much nearer the hinge line in the hind wing than it does in the fore wing. Upon this fact depends the most striking difference in the venation of the fore and hind wings of the adult.

In the fore wing we found that subcosta and radius coalesce to a point near the nodal furrow. But in the hind wing it is only the anterior half of what is left of the radius after the loss of vein R_1 that coalesces with the subcosta. The posterior half,

vein R_{4+5}, separates from vein R_{2+3} very near the base of the wing, and coalesces with the media for a short distance, after which it traverses the wing as a separate vein. A result of this is that while the 1st cell R_3 of the fore wing lies beyond the nodal furrow, in the hind wing it reaches the base of the wing; and the 1st cell R_5 occupies a similar position. A study of the base of the hind wing of the recently emerged adult (Fig. 20) confirms these conclusions.

Other features of interest in the hind wing are the following: The media is only three-branched as a rule, but in some specimens there is a small remnant of cell M_2. The first and second anal veins are widely separate, and the third anal vein is forked.

In the course of the development of the wing of Cicada there is an excellent illustration of the migration of the base of the medial trachea, which was referred to at the close of Chapter II. In the young nymph of Cicada (Fig. 15) the medial trachea arises from the transverse basal trachea midway between the radial and cubital tracheæ. In the mature nymph (Fig. 14) the base of the medial trachea has reached the cubital trachea.

In tracing the homologies of the tracheæ of the wings, it is very important that this migration of the base of the medial trachea be kept in mind. For while in the more generalized forms where there is no basal transverse trachea (Plecoptera and certain Blattidæ) the medial trachea belongs to the costo-radial group of tracheæ, whenever a basal transverse trachea is present the medial trachea either arises from it or is a member of the cubito-anal group. The ontogeny of Cicada gives conclusive evidence of this migration. In all mature nymphs of Hemiptera that we have examined the migration has taken place, the medial trachea being a member of the cubito-anal group.

V. The Venation of the Wings of Heteroptera.

In Cicada we found the most generalized condition of the wings that exists in the hemipterous insects that we have studied, and it is hardly to be expected that a more generalized

form will be found among the living representatives of this order. We have now to consider modifications of this type in representatives of the suborder Heteroptera.

In our studies of Heteroptera we have examined nymphs of the following families: Notonectidæ, Nepidæ, Belostomidæ, Reduviidæ, Nabidæ, Capsidæ, and Pentatomidæ. Of these there is no doubt that the most generalized condition of wing venation is found in the family last named, but further studies in other families may reveal a still more primitive type.

Fig. 21 represents the tracheation of the fore wing of a

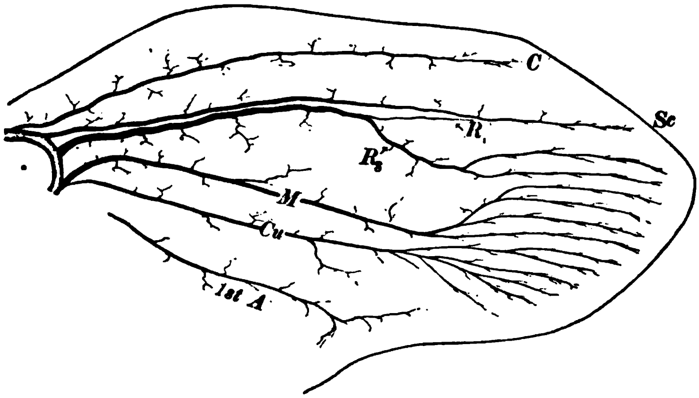

FIG. 21.—A Pentatomid, fore wing, nymph.

Pentatomid nymph. In this wing the costal trachea is well preserved. The subcostal and radial tracheæ are closely approximate in the basal half of the wing; in the distal half of the wing the subcostal trachea traverses that part of the wing which would be traversed by trachea R_1 were it well developed and in its typical position; but it is reduced to a rudimentary condition. It is evident that a supplanting of R_1 by the subcosta takes place here, as in Cicada. The trachea that precedes the radial sector has its characteristic bend at the base, and is two-branched. The medial trachea is typical, that is, four-branched. The cubital trachea is six-branched; it is evident that a specialization by addition has taken place here. Only a single anal trachea has been preserved.

The hind wing of the same nymph (Fig. 22) presents a very similar arrangement of tracheæ, except in a greater reduction of the radius.

Unfortunately, we did not rear any adults from nymphs of this species; hence we cannot give a figure of the adult wing of this particular insect. But an examination of many Pentatomids shows that in the thickened portion of the fore wing the tracheæ follow essentially the same course as in the nymph figured here. There are also faint longitudinal veins in the membranous terminal portion of the wing which doubtless

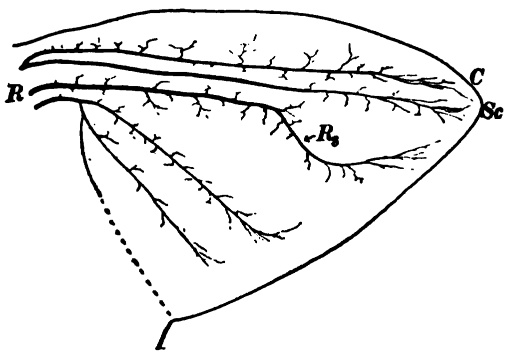

FIG. 22. — A Pentatomid, hind wing, nymph.

correspond with the tips and branches of the principal tracheæ. But at the base of the "membrane," as this terminal portion is designated by writers on the Hemiptera, a hinge line is formed, across which it is rarely possible to trace the tracheæ in dried specimens. The veins of the membrane appear to be connected by cross-veins parallel with this hinge line and close to it, and have but slight connection with the veins of the basal part of the wing except near the end of the anal furrow. We are not able, therefore, with the material at hand, to work out the homologies of the veins of the membrane, and must be content with pointing out at this time the more important features of the thickened portion of the wing.

In those Pentatomids in which we have been able to trace the courses of the tracheæ of the wings, the wing-veins are comparatively inconspicuous. We figure on this account one

of the Coriidæ (***Hormostes reflexulus***) of which we have a specimen in which the tracheæ are distinctly visible within the well-developed veins (Fig. 23).

At the base of the wing the costa is remote from the costal edge of the wing, but approaches it near the middle of the

Fig. 23. — A Coreid, fore wing, adult.

thickened portion. The subcosta and radius coalesce to a point beyond the middle of this part of the wing, where the radial sector separates, making its characteristic curve. Vein R_1 is wanting. Media, cubitus, and the first anal vein extend in nearly direct lines to the membrane.

The most important feature of the venation is the coalescence of subcosta and radius, a feature that occurs in many families of Hemiptera.

But the most important features to be observed are the positions of the furrows of the wing. Here the median furrow is in its typical position between radius and media. In the Pentatomids that we have studied it is more closely parallel with the radius and extends across the radial sector, showing that its position is not determined by the course of the veins. The anal furrow is in front of the cubitus instead of in its more usual position, behind this vein. In fact, in all of the Heteroptera that we have examined, when an anal furrow is distinctly developed it is in front of the cubitus.

Much remains to be done in tracing out the homologies of the wing-veins of the Hemiptera. But we feel that a good beginning has been made, one which will serve as a sure basis for future studies.

VI. The Venation of the Wings of Lepidoptera.

In the order Lepidoptera the primitive type of wing venation is well preserved in certain of the Jugatæ. This is shown in Sthenopis (Fig. 24). In the species figured here, the deviations from our hypothetical type are few. In the fore wing, veins M_4 and Cu_1 coalesce for the greater part of their length, and one of the anal veins has been lost. In the hind wing, veins M_4 and Cu_1 anastomose, but separate near the margin of the wing.[1]

In the Frenatæ we find the primitive type well preserved in the fore wings of the more generalized forms. The most striking departure from our hypothetical type is the fact that the

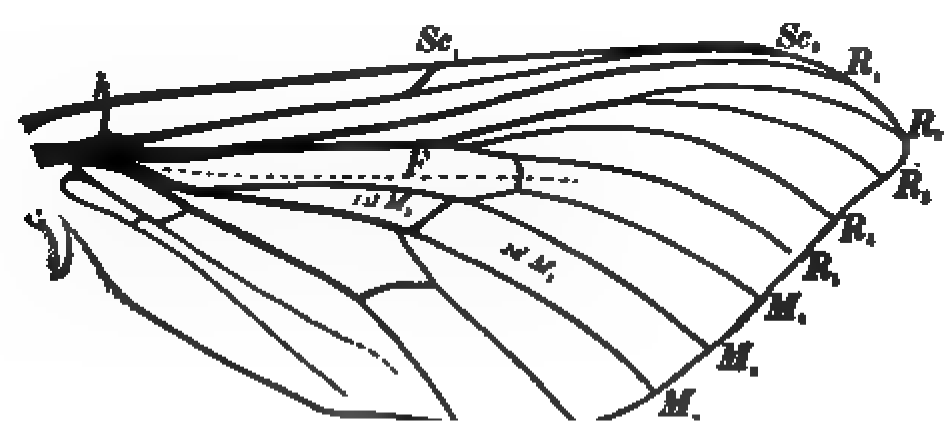

Fig. 24. — Wings of Sthenopis.

media is never more than three-branched;[2] and this is true also of the media of the hind wings. The wings of Prionoxystus

[1] This is not true of the genus as a whole; usually these veins coalesce in the hind wings as in the fore wings.

[2] With our present knowledge it is impossible to determine the way that vein M_4 has disappeared in the Frenatæ. We have seen no indication that it coalesces with vein Cu_1 as in Sthenopis, for in all pupæ of this suborder that we have examined the medial trachea is only three-branched. We are obliged, therefore, to omit any further reference to this vein in the discussion of this order.

(Fig. 25) will serve to illustrate the type of venation characteristic of this suborder.

In the fore wing the branches of radius appear to present a complicated arrangement, but this is merely due to the anastomosis of veins R_3 and R_4; except for this the radial sector has preserved its primitive type. In this wing the bases of veins M_2 and M_3 have migrated towards the cubitus, so that cells 1st M_2 and 2d M_2 are not opposite each other (cell 1st M_2 is the small triangular cell near the center of the wing).

In the hind wing a great reduction of the subcosto-radial

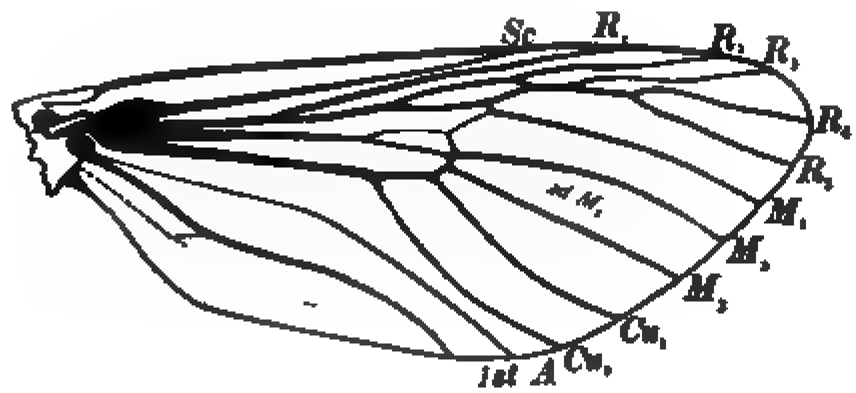

FIG. 25. — Wings of a Prionoxystus.

area of the wing has taken place. This has been brought about in two ways: first, veins *Sc* and R_1 coalesce from the margin of the wing nearly to the base of R_1;[1] and second, the radial sector is reduced to a single vein, R_s.

We have space to point out only one, the most important, of the ways in which this type is modified in the Frenatæ. It will be observed that the basal half of the wing, being traversed by the main stems of all of the veins, is stiffened to a great extent. Evidently, from what has taken place in the more specialized

[1] In pupæ of Frenatæ the subcostal trachea and the first branch of the radial trachea are distinct. This fact was first pointed out by Spuler.

families, there is more vein-material here than is necessary or perhaps desirable, for we find a very general tendency towards the atrophy of the base of the media.

An excellent record of what has taken place is preserved in the fore wing of the adult of Anosia (Fig. 26). Here the base of the media has disappeared, but there remain three little spurs projecting back into cell $R+M$ (indicated by the arrows) which show the positions occupied by the three branches of the media when the base of this vein ceased to be of use. It should be

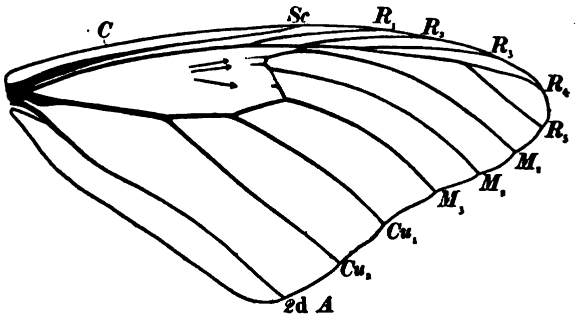

Fig. 26. — Fore wing of Anosia.

observed that in the pupa of this butterfly the medial trachea is well preserved throughout its entire length; the atrophy of the base of the media pertains only to the adult state.[1]

Correlated with the atrophy of the base of the media, there arises a necessity for a new source of air supply for the medial area of the distal half of the wing of the adult, and probably also for a better bracing of this part of the wing than would exist if no other changes were made. These are furnished by a more intimate connection of the branches of the media with the adjacent veins, vein M_1 becoming more intimately connected with the radial sector, vein M_3 with cubitus-one, and vein M_2 with one or the other of these veins, differing in different families.

There result from the changes just pointed out striking modifications of the courses of the veins concerned. Note, for example, that the base of vein M_3 in Anosia (Fig. 26) has

[1] Figures of the wings of pupæ of Lepidoptera are omitted, as several have been published by Spuler and others.

migrated away from the spur indicating its more primitive position, and that the medio-cubital cross-vein (*m-cu*) is no longer transverse, but appears to be a continuation of the main stem of the cubitus.

VII. The Venation of the Wings of Trichoptera.

In the preceding pages much evidence has been given to show the importance of studying the tracheæ that precede the wing-veins, in order to determine with certainty the homologies of the latter. But in some of the orders of insects a remarkable reduction of the wing tracheæ has taken place, which renders them useless for this purpose. This is true of the Trichoptera and Diptera, and also to a considerable extent of the Hymenoptera.

Fig. 27. — Wing of a pupa of a caddice fly.

If the wing of a pupa of a caddice fly be examined at that stage when the forming wing-veins appear as pale bands, it will be seen that the tracheation of the wing bears but little relation to the wing-veins. Usually only two or three main tracheæ are present; and although these may coincide with forming veins, their branches bear no relation whatever to veins (Fig. 27).

Fortunately, in the case of the Trichoptera we do not need to study tracheæ in order to determine the homologies of the wing-veins; for here, in the more generalized members of the order, we find the primitive type of wing venation well preserved.

The fore wing of Hydropsyche (Fig. 28) with a slight modification would serve as a typical insect wing. Excepting the coalescence of anal veins at the tip, the number and arrangement of the longitudinal veins in this wing correspond exactly with our hypothetical type; and only those cross-veins are present that may be considered typical on account of the fre-

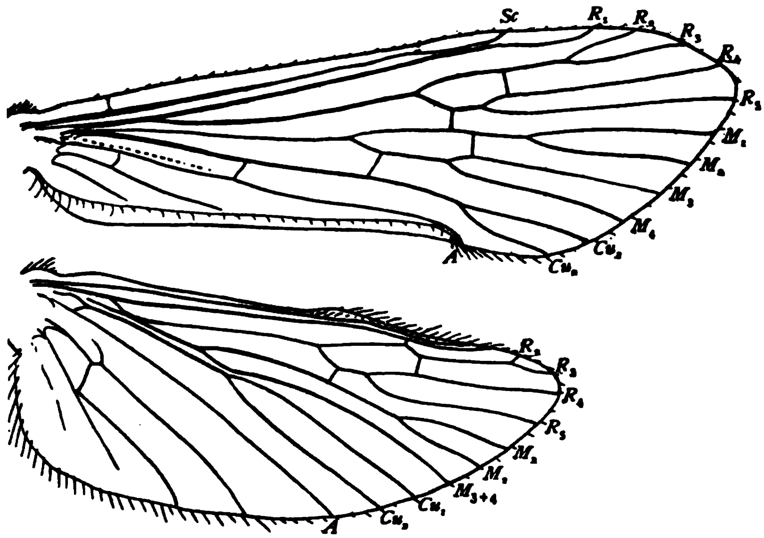

FIG. 28. — Wings of Hydropsyche.

quency with which they occur in the more generalized members of different orders.

In the hind wing the media is only three-branched and a tendency towards an increase in the number of anal veins is evident. This expansion of the anal area of the hind wings has been carried to a considerable extent in certain members of the order.

Lack of space prevents a discussion of the various ways in which the primitive type of wing venation is modified within this order. But such a discussion is hardly necessary, for it is not difficult to understand the venation of the wings of these insects.

ENTOMOLOGICAL LABORATORY,
CORNELL UNIVERSITY, January, 1898.

BRIEFER ARTICLES.

A CASE OF VARIATION IN THE NUMBER OF AMBULACRAL SYSTEMS OF ARBACIA PUNCTULATA.

HENRY L. OSBORN.

The growing interest in variation, stimulated by the appearance of Bateson's[1] work on that subject, seems to make it worth while to record cases of variation even where they are isolated, and it is for this reason that I make the following record. The specimen is the only one thus far met with in the course of several years in using Arbacia and Strongylocentrotus, so that it can be regarded as rare. The number of Arbacias that have passed through my hands cannot be less than two hundred, and of Strongylocentrotus, not less than twice that number, and I have not before met a case in which the number of ambulacral systems was less or more than five. I was, therefore, somewhat surprised when a student presented me with a drawing of an Arbacia in which the number was four, and at first was inclined to doubt the accuracy of the work; but the specimen itself was placed in my hands and showed that this departure from the typical number does occur in this species.

The specimen came to me dried. It came from Woods Holl in a lot of supplies furnished by Mr. W. H. Walmsley, and the position

Aboral and oral aspects of a four-rayed individual of Arbacia punctulata from the coast of Massachusetts.

of the soft parts can only be inferred from the test, which, however, is fairly indicative of the internal anatomy in this class of animals. Two views of the test are shown in the accompanying cut. That of

[1] *Materials for the Study of Variation.* Macmillan, 1894.

the oral surface is perfectly four-rayed instead of five. Four perfect ambulacral rows alternate with four perfect inter-ambulacral rows. On the aboral side, too, the ambulacral rows are completely four-rayed instead of five-rayed. The lantern, too, is completely four and not five-parted; its relation to the peristome membrane is apparently the same as in the normal cases. But a break in the four-rayed plan occurs in the aboral ring of bones. In this ring there are three large genital bones which terminate rows numbered 1, 2, and 3 of the figure, No. 1 being the madreporic plate; but the fourth row is terminated by two smaller genital bones, each perforated for the opening of the genital duct. One of these bones is at the summit of one of the two rows of bones in the inter-ambulacral area, and the other is at the summit of its mate. There are, however, only four instead of the normal five ocular plates. The position of the anal plates is normal, *i.e.*, there are four, and the plane between two passes through the madreporic plate at the summit of area No. 1. The test as a whole is entirely symmetrical, and the variation is not betrayed by any even slight loss of symmetry; the outline is quadrilateral, not pentagonal as usual.

It seems from the study of the test that what has happened has been the failure of one entire ambulacral system to appear, that is, two ambulacral rows of bones and the neighboring inter-ambulacrals on each side have not developed at all, while as a consequence the inter-ambulacrals of two rows, *viz.*, that on the left side of row No. 4 and that on the right side of row No. 5, have been matched together, so that row marked actually No. 4 is really a part of row No. 4 and a part of row No. 5, the balance of each having been suppressed so early that there is no trace of them left. The apical organs, however, were not included in this suppression, and hence the genital plates, and presumably the reproductive organs as well, are in fives.

This case does not exactly correspond with any of the cases cited by Bateson (pp. 443 *et seq.*), for his list does not provide for a case in which there is a total variation to a four-rayed form in the ambulacrals and inter-ambulacrals, and perfect symmetry among these parts, and at the same time only partial approach to the four-rayed form in the apical system. His case No. 676 (p. 441) is totally four-parted, and there are four genitals and four oculars, and case No. 677 also has the apical system, as well as the ambulacrals four-parted. The only cases of partial meristic variation which he gives are those in which some of the ambulacral systems are partly subdivided by the intercalation of some of the missing bones. The presence of the

five genitals makes it possible to conclude that in this case the missing ambulacral row (using the nomenclature of Lang, *Comp. Anat.*, vol. ii, p. 321, Macmillan, 1896) is the right posterior one.

BIOLOGICAL LABORATORY OF HAMLINE UNIVERSITY,
ST. PAUL, MINN., February 1, 1898.

RELATIONSHIP OF THE CHRIACIDÆ TO THE PRIMATES.

CHARLES EARLE.

IT would be interesting if some especially clear-headed paleontologist would define the order Creodonta and explain how it is to be separated from the Insectivora. If we include forms like Chriacus in the Creodonta, we shall be obliged to follow Wortman's suggestion and unite the creodonts and insectivores in one common group.

It must be granted that the creodonts of the Puerco were well differentiated and somewhat specialized; this is proven by the presence of such forms as Deltatherium and Didymictis, the latter genus having developed already the true sectorials of the higher carnivores. It remains to be shown whether the peculiar upper molars of the Mesonychidæ are primitive or degenerate. If Dissacus is really the ancestor of Mesonyx, then this series illustrates an important point in tooth morphology, and would help to settle the vexed question whether the order of appearance of the cusps of the true molars is really different from that of the premolars. In Dissacus and Pachyæna, for example, one would be led to conclude that the antero-external cusp of the upper molars was the first one to appear and its position had not been changed. In the case of these teeth it is hard to believe that there had been any rotation inwards of the protocone such as the advocates of the triconodont-tritubercular theory would make us believe.

The genus Chriacus and its allies have little in common with the above-mentioned creodonts, and I fail to see why they should be classified with them. It appears to me to be out of the question to imagine that the primates have any close relationship to the Condylarthra such as Cope supposed. That the condylarths were all ungulate types has been admitted, and, in fact, it is one of their important diagnostic characters that they were hoofed quadrupeds.

It has been most interestingly shown by Dr. W. D. Matthew how closely one of the earliest condylarths, Euprotogonia, approaches in

the structure of its skeleton that of the creodonts, and it appears most probable that these primitive hoofed forms came from clawed types. Now Hubrecht, on embryological grounds, derives the most primitive of living lemurs, Tarsius, from an insectivorous-like ancestor. I have endeavored to prove that all lemurs must have originated from unguiculate types, and that the anatomical characters which the extinct and living lemurs have in common with the ungulates probably arose independently of the latter.

It is very curious, if the mammals of the Puerco were such primitive forms, that this fauna contains so few types which led up to later genera. Among the generalized types of the Puerco I think we can designate Chriacus as such, and I believe that it may be related ancestrally to that curious group of pseudo-lemurs, the Hyopsodontidæ. Now Hyopsodus has a skull resembling very closely that of Adapis, although the structure of the teeth in these genera is absolutely different. What is known of the skeleton of Adapis shows that the proportions of the limbs are similar to what is found in Nycticebus, the anterior limbs not being elongated as in Tomitherium.

I fail to see that any new evidence has been brought forward to prove that Chriacus is not a primate, or, better, an insectivore related ancestrally to the Bridger pseudo-lemurs, Pelycodus and its allies. Surely the structure of the teeth in Chriacus is more like an early primate or insectivore than that of any of its contemporary creodonts of the Puerco. The spacing of the premolars in Chriacus is no objection to its being related to the primates, for among living lemurs we meet with forms with slight intervals in their dentition. Again, the large canines of Chriacus are like those of Pelycodus or Adapis, and the long, slender jaw may be considered a primitive primate character.

In conclusion, it appears to me that the Chriacidæ would find a more "congenial location" either in the Insectivora or as very primitive primates which had just emerged from the former group. If the Chriacidæ can be conveniently placed among the Insectivora and are shown to be related to Pelycodus and related forms, then a decided advance has been made in connecting the later Eocene group of primitive American lemurs with those of the Puerco.

NEW ROCHELLE, N.Y.,
January 10, 1898.

FURTHER NOTES ON THERMOMETER CRICKETS.

CARL A. BESSEY AND EDWARD A. BESSEY.

THE article on "The Cricket as a Thermometer" by Professor Dolbear in the November *Naturalist* reminds us of a series of somewhat similar observations upon the chirping of the tree cricket (*Œcanthus niveus*) which we made in Lincoln, Nebr., during August and part of September of the past summer.

Noticing that the rate of chirping was approximately the same in different parts of the city for any particular time, but that this rate varied in a marked degree from day to day, we were led to make an investigation of the conditions accompanying these variations. We began taking observations upon this rate along with thermometer readings on August 13.

Finding that each cricket remained in the same tree for days at a time and that in different trees the rate was often slightly different, we thought best to take a series of observations on certain individual insects. These were designated for convenience as A, B, C, etc. For example, we found that at a temperature of 66.5° F., B chirped 122, E 121, F 122, and G 118 times per minute. Through a quite wide temperature range G almost invariably chirped at a lower rate than either E or F.

Observations were made on the rate of chirping of eight different crickets for periods ranging from a few days to about three weeks. Some could be distinguished for only a few days, while others, notably E and F, chirped very regularly every evening for three weeks or more. On evenings when the temperature was falling rapidly, observations were made several times, with results very markedly showing the effect of temperature change. For A five different observations were made, for B nine, C four, D one, E thirty, F twenty-two, G ten, and H five.

One cool evening a cricket was caught and brought into a warm room. In a few minutes it began to chirp nearly twice as rapidly as the out-of-door crickets. Its rate very nearly conformed to the observed rate maintained other evenings out of doors under the same temperature conditions.

From this series of observations we found that the rate of chirping was, as Professor Dolbear says, very closely dependent on the temperature.

Plotting the chirps per minute as ordinates, and temperatures (degrees Fahrenheit) as abscissæ, we obtained a series of points whose maximum deviation from a straight line was only about six per cent. From this we deduced the relation

$$T = 60 + \frac{N - 92}{4.7},$$

where T stands for temperature, and N for chirps per minute. For temperatures between 60 and 80 this equation is accurate within one

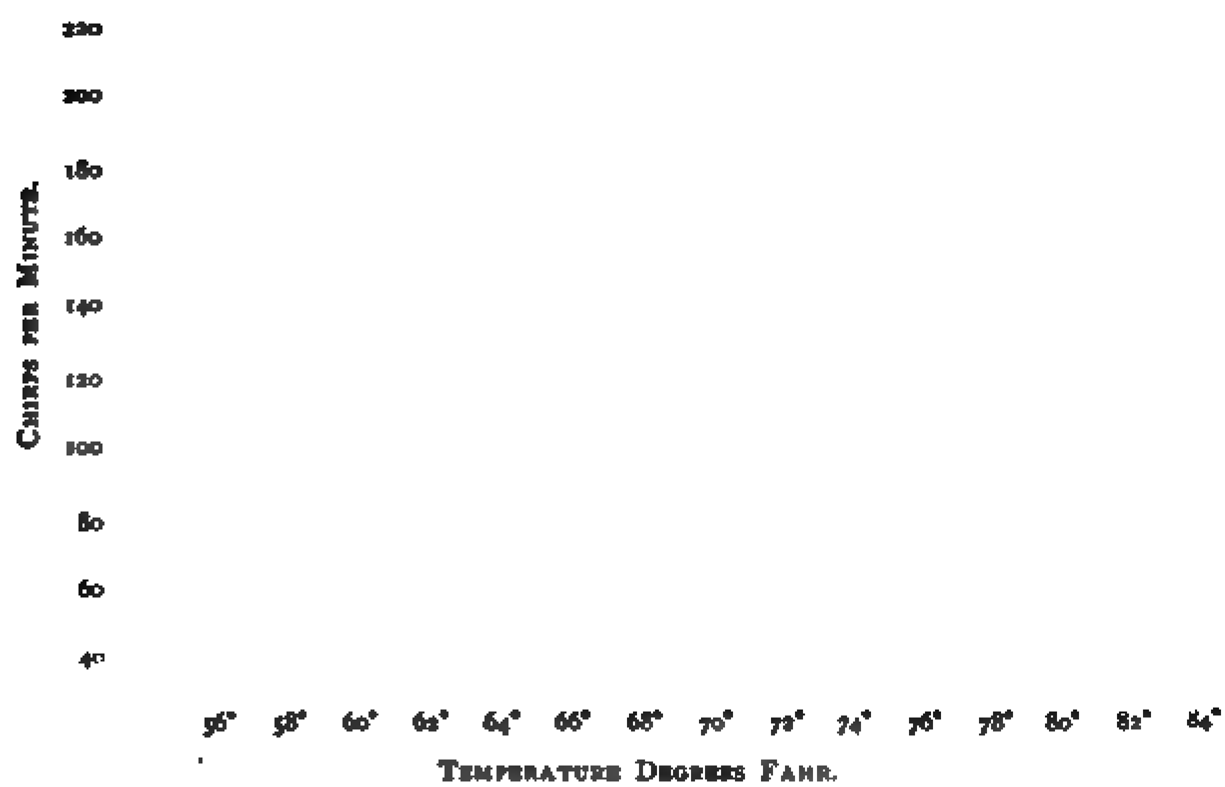

Figure showing the correspondence between temperature and rate of chirping. The solid straight line conforms to the formula; the dotted curved line is evidently somewhat closer to the observed facts.

or two degrees. Below 60, however, the insects chirp at a somewhat faster rate than would be expected from the formula, and consequently the calculated temperatures would be two or three degrees too high.

This deviation shows that the actual relationship between the rate of chirping and temperature cannot be exactly expressed by a straight line, as in our diagram, but should rather be expressed by a curve approximating that shown in the figure by the dotted line.

The University of Nebraska.

POLLINATION OF THE CLOSED GENTIAN BY BUMBLEBEES.

R. J. WEBB.

On the morning of Sept. 3, 1897, while walking by a moist spot, I came across a fine cluster of the closed gentian (*Gentiana andrewsii*). My attention was also attracted by three or four bumblebees which were buzzing among the flowers, and, watching these, I saw that they were working upon the blossoms of this plant.

One of them poised itself above a flower and inserted its proboscis in the dimple formed by the overlapping plaits, and by dint of considerable exertion and wriggling and twisting about, it was able to force the corolla open and crawl in until it reached the nectar which is found at the base of the tube. It remained thus partly in the flower for four or five seconds, then backed out and flew to another blossom. This operation was repeated many times, for I watched the same bee enter fifteen or twenty flowers, and the others were also working away at the same time. They usually crawled in until about half inside, and while in this position would often kick and twist about. All the insects' strength was required to force open some of the flowers, and the ones which were immature and hence not ready for fertilization they were unable to enter at all.

On October 4 I examined the same patch and found nearly every capsule full of perfect seeds.

This would seem to show that the plant is entomophilous and is fertilized by bumblebees, as was believed by Dr. Gray, who once saw one of them force its way into the corolla. Dr. Kunze and others have regarded this plant as autogamous.

Garrettsville, Ohio.

EDITORIALS.

National Scientific Appointments. — The history of the Smithsonian Institution, considered in the previous issue, is a highly creditable one. That it is so is doubtless due to the high character of its secretaries. In their eminent fitness for the positions they have filled they constitute a striking contrast to the series of heads of other governmental scientific bureaus. The reason for this contrast is doubtless the different method of appointment. The chief of many scientific bureaus is appointed by the President, who is subjected to the importunities of politicians who have a debt to pay to some political friend. Such importunities it is more than human always to resist. The President should be relieved from them in the case of the scientific bureaus. The experience of the Smithsonian Institution suggests the method. The secretary is here appointed by the Board of Regents, composed of the Chief Justice of the Supreme Court of the United States, who is also the presiding officer, the Vice President of the United States, three Senators appointed by the Vice President, three members of the House of Representatives appointed by the Speaker, and two citizens of Washington and four "citizens of a state" appointed by joint resolution of Congress. Such a committee, meeting at least once a year, soon catches the spirit of the Institution, and seeks only its best interests; at the same time it keeps the bureau in touch with Congress, to which it looks for appropriations. Another point: the two secretaries who have succeeded Henry have held the office of first assistant secretary. Thus a continuity in the administration of the office has been secured. The moral of the experience of the Smithsonian Institution is that the appointment of the chiefs of our national scientific bureaus should be made by boards composed of scientific men and members of Congress, who shall keep in touch with the workings of the bureau, and shall, as far as possible, in their appointments follow the principle of promotion.

A Uniform System of Craniometry. — The deplorable lack of harmony which still exists in the measurements and methods of craniologists is discouraging to the student, and renders the results obtained by each observer of less value to others for compara-

tive purposes. The selection of a common series of cranial measurements does not present the practical difficulties that oppose the adoption of the coming international scientific language. The number of measurements having a practical ethnic or descriptive value is less than one hundred; nearly all of these have been in use for years, and their relative importance has been pretty accurately determined. The spirit of courtesy and fairness which characterizes the true scientist should induce each one to sacrifice some of his allegiance to tradition, in order that a system may be devised that shall require no explanation, and which shall be as accessible to the Russian as to the American. We may be ready to accept in this list some measurements having their origin even at that elusive and indeterminate point the ophryon, if thereby the desired end shall be the sooner reached.

The number of measurements taken by the French and English is so large that the investigator is involved in a mass of calculations and tables that require an expenditure of time by no means commensurate with their importance. We recognize the fact that these measurements have a certain value, but we think that the principal facts regarding the size and proportions of the human cranium can be learned from not more than forty measurements and indices; doubtless certain crania will admit of unusual measurements, and a short supplementary list may be desirable, but the essential measurements should be taken in any case.[1] The French system is the oldest, and the system to be advocated should be based upon the *Instructions Craniologique* of Broca.[2] The successors of this distinguished anthropologist have improved upon the system as at first

[1] The number of measurements and indices taken by the different schools is shown in the following list:

Broca	84, Sur Les Cranes de la Caverne de l'Homme Mort. Paris, 1879. In the *Revue d'Anthrop.*, ser. 2, vol. v, p. 578, Topinard states that the number of measurements and indices used by Broca in his study of the crania of contemporary Parisians from the Cimitière de l'Oust was 103.
Topinard	65, *Éléments d'Anthropologie Générale*, p. 979. Paris, 1885.
Quatrafages	79, *Crania Ethnica*, p. 9. Paris, 1882.
Flower	57, *Journ. Anthrop. Inst.*, vol. ix, p. 107.
Duckworth	60, *Journ. Anthrop. Inst.*, vol. xxvi, p. 285.
Frankfort Agreement	42, *Archiv. f. Anthrop.*, Braunschweig, Bd. xv, s. 1.

[2] *Mem. Soc. d'Anthrop.*, 2d ser., 1875. Tome ii, p. 25.

outlined. The Germans, foremost among whom stands the venerable Virchow, have also grown away from the Frankfort agreement. The English, under the leadership of Sir William Flower, have based their work upon that of Broca. The Americans, without any leader devoting himself exclusively to somatology, have furnished some original contributions of no mean value.

The American Association for the Advancement of Science is to celebrate its semi-centennial at the coming meeting. The occasion will be fittingly observed, and it is hoped will be marked by the largest attendance in the history of the Association. The section of anthropology has always been one of the best attended, and most of those interested in somatology will probably visit Boston in August. Can we not take advantage of this opportunity to make the preliminary move toward a uniform system of craniometry? Such a congress meeting in this vicinity would have the further advantage of access to collections of crania and craniometrical instruments for purposes of illustration.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

The Aborigines of North-West-Central Queensland.[1] — The Australian aborigines are now ranked by ethnographers as fifth or sixth in the list of so-called natural races, the Veddahs of Ceylon being the lowest in the scale of savage culture. A few Anglo-Australians have appeared as earnest champions of the "Blacks," but the superior race commonly regards them as brutal and degraded, and the advent of the whites has been an even more disastrous event to the aborigines than in America. Disease, alcohol, and lead have rapidly reduced their numbers. A thorough and comprehensive study of the Australian tribes has never been attempted, and the information now obtainable from the miserable remnants of the race can afford us but an imperfect knowledge of their former condition. It is to be regretted, therefore, that such painstaking investigations as those of Dr. Roth were not made a century ago. The territory embraced in these *Ethnological Studies* is designated North-West-Central Queensland and lies beyond the region described by Lumholtz.

The book contains 184 pages of text, about one-third of which is devoted to the language of the twelve tribes that occupy that portion of the colony. The elementary grammar and the list of words selected for tabular comparison from the various dialects supply a much better basis for further linguistic study than the meager vocabularies previously published from that quarter. A vocabulary of about 600 words of the Pitta-Pitta dialect is given and about 200 more are included in the grammar. From the large number of vowel sounds we can easily believe the statements of other writers that the language is "soft, vocalic, and melodious."

We are led to infer that the sign-language is not very generally known to the whites, rather than that it is but rarely practised by the aborigines, as is stated by other writers. A recent authority declares that these northern tribes are more intelligent than those of South Australia. Another writer, however, asserts that the southern tribes are the more intelligent. The message sticks figured are inferior to those of East Australia. The remarkably complex nomenclature of

[1] *Ethnological Studies among the North-West-Central Queensland Aborigines.* By Walter E. Roth, Brisbane, Government Printer, 1897.

classes and individuals is described in detail and rendered more easily comprehensible by a table, or family tree. The decorative art of these people seems not to have passed that primitive form of expression exhibited in body painting; the patterns used are shown in color drawings. Rock paintings are almost unknown. The various kinds of vegetable and animal foods are enumerated and some account given of their preparation. No mention is made of those fruits and bulbs which in other parts of the continent are rendered innocuous by elaborate preparation before they can be used. We notice that the green ant is eaten raw. The method of capture differs somewhat from that in vogue elsewhere; instead of allowing the ants to crawl up a stick into the mouth of the hunter, he stamps upon the ant-hill until the ants run up his legs, when they "get scraped or swept off as fast as they come up."

A chapter is devoted to the subject of sports and festivals, including an account of the Molonga set of corroborees which require five nights for their completion.

The most interesting and valuable part of the work is that dealing with the medical practice and the superstitious rites and ceremonies of the aborigines. This sort of material is the most difficult to obtain from savages, or, for that matter, from people in any grade of culture. The subject of religion is not separately treated, and the incidental references are unsatisfactory and incomplete. Careful inquiries were made, but all the information obtained is summed up in a single sentence: "In his natural state, the fear of death is but as nothing to the savage; he has a hazy notion of the corpse 'getting older and moving about elsewhere' when he ceases to bring food and tobacco any longer to the burial-place; he has no dread of future punishment, no hope of reward in another life." Dr. Roth's professional training and familiarity with the Boulia language enabled him to thoroughly investigate the causes and results of the mutilations practised by these people; his conclusions tend to disprove the accepted theories accounting for the mika operation. The brief papers of Miklukho-Maclay and the accounts of other writers have given some information concerning these ceremonies and the sexual relation in general, but the present work is the most complete that has yet appeared.

A very full index and glossary is furnished. Drawings to the number of over 400 add materially to the value of the work, though the arrangement of the explanations of the plates at the beginning of the volume is not a convenient one.

GENERAL BIOLOGY.

Studies on Protoplasm.[1] — The author has here given a summary of her studies made during ten years upon protoplasmic phenomena. She recognizes that the study of living protoplasm, as opposed to preserved and tortured states, may to-day hope for some scattered sympathy. Her studies were unhampered by theory or predilection, except what may be described as a belief in life genii more complex and more potent than even surface tension and osmosis. The author has avoided controversial references, although arguing for Bütschli's foam theory of protoplasmic structure. The new facts brought forward, while not *explaining* phenomena, serve to *unify* them. The book contains 176 pages.

It is difficult to summarize this work, but certain main points may be noted. Not only is Bütschli's foam theory accepted, but it is extended by supposing, on the evidence of certain appearances which are described, that the walls of the alveoli of Bütschli are themselves made up of vesicles; and apparently their walls, in turn, may be vesiculated, and so on indefinitely. The continuous substance forming the walls of the vesicles is the true living matter, the material included in its spaces being merely passive.

The protoplasmic foam is found to have a structure in areas where the functions are chiefly vegetative which differs somewhat from the structure when the manifestations of contractility and irritability predominate.

The continuous substance is described as being commonly in a state of flux, or of active contraction. The spinning out of fine filose processes from protoplasmic surfaces was found to be of almost universal occurrence and is regarded by the author as of fundamental importance. These spinnings may be internal as well as external to the mass.

A "new structural formula for protoplasm" is given as follows (p. 106):

"Protoplasm is a very complex emulsion, having the physical arrangement of a very finely subdivided, variably viscid foam, which characters are coextensive with the continuous element of all visible optical reticula."

"The substance which at any given moment forms in all sub-

[1] The Living Substance: as Such: and as Organism. By Gwendolen Foulke Andrews. Boston, Ginn & Co., 1897. Supplement to the *Journal of Morphology*, vol. xii, No. 2.

divisions of the foam the continuous element varies its viscosity by some unexplained changes within its finer structure, so that from a fluid state it may almost instantly become viscid to varying degrees, even to a semblance of true solidity. It is subject to displacement by contraction activity which may be rhythmically organized or may be of a filose nature. . . .

"The continuous substance is at any given moment the physiologically active element of protoplasmic masses. . . . Upon its response in character of its powers, or properties, to specific and general environment depend all the physiological phenomena characterizing areas, masses, or organisms as such. It is homogeneous throughout all areas alike, as to its intrinsic powers and characters, but not as to the specific, or habitual, expression of these, which varies with its chemical or physical contacts."

The discontinuous elements, or protoplasmic inclusions, are heterogeneous in character and form the "specific environment" of the living substance. This is regarded by the author as the most important source of the stimulus which determines the course of protoplasmic activity.

The author's position in regard to the cell theory recalls the view of Wolff that the cell is not a fundamental unit, but merely an incidental expression of the vital activities of the continuous living substance. Although not expressed in these terms, she appears to agree with Driesch and Hertwig in regarding the differentiation of an area as a function of its position.

This is enough to give an idea of the scope and tenor of the book, which the reader, if not discouraged by a style which at times renders comprehension difficult, will find to contain much that is suggestive and interesting.

Isolation and Physiological Selection.[1] — Professor C. Lloyd Morgan has earned the gratitude of all biologists by completing the work so well begun by Romanes. The third and last volume of the *Darwin and after Darwin* was issued late in 1897. Of this the first two chapters and the last were in type at the time of the death of the author. The material in the remaining three chapters has been selected and arranged by Professor Morgan.

The first two chapters are devoted to a general discussion of the principle of isolation. "Equalled in its importance by the

[1] G. J. Romanes, *Darwin and after Darwin; III, Post-Darwinian Questions: Isolation and Physiological Selection.* Chicago, Open Court Pub. Co., 1897.

two basal principles of Heredity and Variation, this principle of Isolation constitutes the third pillar of a tripod on which is reared the whole superstructure of organic evolution." Natural Selection is regarded as merely a special case of isolation when the best fitted are separated from the less fit by the death of the latter. The following chapters are concerned with another special case of isolation, namely, Physiological Selection. Here are brought together in convenient form the chief facts and arguments in regard to this important subject. This is followed by a chapter giving a brief history of the opinions on isolation as a factor of organic evolution, and the general conclusions of the whole work are summed up in a final chapter.

The book is largely controversial in tone, and the arguments are presented, of course, from the standpoint of the well-known views of the author. Still, the other side is at least given a hearing, and we have in the three volumes as a whole what we have not had before, — a complete work on organic evolution reflecting the thought of recent times.

ZOOLOGY.

A Viviparous Holothurian. — The life histories of the few holothurians that protect their young during the early stages of their development afford some most peculiar and interesting instances of adaptation, as regards both structure and habits.

The transference of the eggs in *Cucumaria planci* to an atrium in front of the mouth and encircled by the tentacles, there to be fertilized by spermatozoa thrown out by a neighboring male into the surrounding water, which is swept into the atrium by the movements of the tentacles of the female, is well known from Selenka's account of the process.

We are also acquainted with the conditions in *Cucumaria glacialis* Ljungman in which Mortensen[1] describes a pair of broad pouches, invaginations of the body wall in the ventral interradii, immediately behind the circle of tentacles. The large yolk-filled eggs (diam. 1 mm.) after being laid are presumably taken up by the female from the sea bottom into the pouches. Similar brood sacs are found in another Arctic species, *Cucumaria minuta* Fabr., and in *C. laevigata* Verr. of the Antarctic seas.

[1] Th. Mortensen, Zur Anatomie und Entwicklung der Cucumaria glacialis (Ljungman). *Zeit. f. wiss. Zool.*, Bd. lvii, pp. 704–732, Taf. 31, 32. 1893.

Another curious adaptation has been described by Ludwig[1] in *Chirodota contorta* Ludw., also from the Antarctic. In this animal the reproductive tubules themselves serve as receptacles for the young until they have attained a length of 3 mm. or more, when birth takes place through the outer opening of the genital duct.

Furthermore, the attachment of the eggs of *Cucumaria crocea* Less. and of *Psolus ephippifer* W. Thoms. to the dorsal surface of the mother, where the young are reared, is a fact that is familiar to all naturalists.

In still other holothurians the eggs have been known to find their way in some hitherto unexplained manner into the body cavity, where they develop. One of these forms is *Synapta vivipara*, originally described by Oerstedt from specimens taken in the West Indies. It is probably identical with Theél's *Synapta picta*, which the Challenger Expedition took at the Bermudas.

Synapta vivipara has recently been thoroughly studied by Dr. Hubert Lyman Clark[2] in the Johns Hopkins Marine Laboratory at Port Henderson, Jamaica. It is to be found in the quiet pools in the rear of Port Royal, clinging to the red seaweed Acanthophora, which is attached to the roots of the mangroves.

The eggs probably burst through the thin walls of the bisexual reproductive tubules into the body cavity; they were never observed in the genital duct, nor were passages from it into the body cavity discovered. The duct runs forward into the body wall, but ends blindly in the connective tissue beneath the external epithelium.

Spermatozoa were found abundantly both in the duct and in the connective tissue about its blind end; hence it is believed that they pass outward through the epithelium of the end of the duct, the connective tissue layer, and the thin external epithelium of the body wall. Thence they are believed to make their way to another individual, and by passing inward through the anus and certain apertures in the walls of the rectum into the body cavity they meet the ova.

Apparently ripe spermatozoa and ova occur simultaneously in the same reproductive tubule, but there is nothing to indicate that the spermatozoa ever pass from its lumen through its wall into the body cavity. Indeed, no direct evidence has been obtained to show either that self-fertilization does or that it does not take place in *Synapta vivipara*.

[1] H. Ludwig, Ein neuer Fall von Brutpflege bei Holothurien. *Zool. Anz.*, Jahrg. xx, Nr. 534, pp. 217–219. 1897.

[2] H. L. Clark, Synapta vivipara: A Contribution to the Morphology of Echinoderms. *Memoirs Bost. Soc. Nat. Hist.*, vol. v, No. 3. 1898.

H. L. Clark, The Viviparous Synapta of the West Indies. *Zool. Anz.*, Jahrg. xix, Nr. 512, pp. 398–400. 1896.

Without considering in detail the development of the larvæ, we will discuss certain features of the process which are of such especial interest as to merit the attention of the general reader.

The ciliated gastrula which swims freely in the body cavity of the mother presently becomes transformed into an oval embryo without ciliated bands; a mouth at this stage is found upon the ventral surface of the body, but there is no anus; the blastopore has closed. A pair of cœlomic pouches are present, as well as a hydrocoel, which has upon its anterior face five large interradial outgrowths (the canals of the primary tentacles) and five smaller *radial* outgrowths, each of the latter being situated at the right of one of the former. An *adradial* water canal opens upon the surface of the body by a dorsal pore.

Thereupon follows a *pentactula* stage in which the hydrocoel, its extremities having united near the mid-ventral line, forms a ring; a Polian vesicle is present in the left-dorsal interradius; the central nervous system has been established, the nerve ring having been derived from a thickening of the ectoderm which surrounds the mouth, the radial nerves, as well as nerves to the tentacles, having arisen as outgrowths from the circular nerve band; five pairs of otocysts lie external to the radial nerves at the point where they bend to run backward; the mouth, situated in the center of a circle of tentacles, opens into an œsophagus lined with endoderm; the stomach is large; the intestine makes a single loop; an anus is now present at the posterior extremity of the body; a mesentery, formed by the fusion of the right and left cœlomic pouches, attaches the alimentary tube throughout its whole extent to the body wall.

The pentactula then becomes transformed directly into the larva with ten tentacles which, when it has attained a length of about 5 mm., is set free from the parent. In some cases, however, young individuals 15 mm. or 20 mm. in length have been observed still within the body cavity of the mother. Birth takes place by the rupture of the body wall near the anus, or, more frequently, by a perforation through the wall of the rectum, in which case the young finally escape through the anal opening.

The most striking feature of the abbreviated course of development of *S. vivipara* is the complete lack of radial water canals of the body wall, even in the embryo. It seems to be definitely determined[1] that in *S. digitata* these canals are formed in the early stages of

[1] R. Semon, Die Entwickelung der Synapta digitata und die Stammesgeschichte der Echinodermen. *Jena. Zeit.*, Bd. xxii, pp. 175–309, Taf. 6–12. 1888.

development, and it is equally certain that in the adult of this same species, as well as in many or all other Synaptidæ, they are entirely lacking.[1] In *S. vivipara* the five primary interradial outgrowths of the hydrocoel grow forward and constitute the canals of the five primary tentacles; the five secondary radial outgrowths extend forward, each to a point immediately in front of which a radial nerve passes outward in its course to the body wall. From three of the radial outgrowths of the hydrocoel branches soon arise, which grow forward on either side of a radial nerve and form the basis of the accessory tentacles; from the fourth or left-dorsal radial outgrowth a single branch arises, ventral to the radial nerve, forming an accessory tentacle of the left-dorsal interradius; whereas the fifth or mid-ventral outgrowth is never more than a slight protuberance, from which no accessory tentacles are normally developed, and which usually soon atrophies and disappears. None of the radial outgrowths of the hydrocoel is prolonged to form a radial canal in the body wall.

From the fact that no radial canals are ever developed in *S. vivipara* it is evident that we have in this form a more degenerate condition of the water vascular system even than in *S. digitata.* The fact that the stone canal in the adult *S. vivipara* has an opening directly upon the surface of the body, with a madreporite near the body wall having openings into the cœlom, would seem to indicate, on the other hand, that in this one particular the water vascular system has retained its primitive structure.

When, furthermore, we compare the water vascular system of the larva of *S. vivipara* at the stage with ten tentacles with that in Cucumaria at a similar stage, as described by Ludwig,[2] we find strikingly similar conditions. If the Synaptidæ have been derived, as Ludwig has suggested, from an ancestor the tentacles of which arose as branches from five radial outgrowths of the hydrocoel, and if we should, furthermore, suppose that subsequently by the gradual shortening of those outgrowths the five primary tentacles came eventually to arise directly from the hydrocoel ring, losing their immediate connection with the radial outgrowths, then we would have a complete homology between the conditions which Dr. Clark has found in *S. vivipara* and those in Cucumaria as described by

[1] H. Ludwig und P. Barthels, Zur Anatomie der Synaptiden. *Zool. Anz.*, Jahrg. xiv, pp. 117–119. 1891.

[2] H. Ludwig, Zur Entwickelungsgeschichte der Holothurien. *Sitzungsber. k. preuss. Akad. Wiss.*, Nr. 10, pp. 179–192; Nr. 32, pp. 603–612. 1891.

Ludwig. Unless this assumption is made, however, the evident correspondence between the secondary tentacles of the two forms which Dr. Clark has pointed out would mean nothing, because the primary tentacles would not be homologous.

This entire assumption is plausible for these reasons: (1) there is an evident degeneration of the water vascular system of the Synaptidæ which would be expected to affect first the primary tentacles; (2) the primary tentacles can more easily be supposed to have originally sprung from radial canals than *vice versa*, since the secondary tentacles, in fact, are known to arise from radial canals, whereas there is little evidence in favor of the view of Semon that the tentacles in the primitive holothurian arose directly from the circular water canal.

An abundance of anatomical and histological evidence could be given to show that the Synaptidæ are more closely related to the Molpadiidæ (*e.g.*, Caudina) and their allies the Cucumariidæ than to any other groups of holothurians. Hence we may, as suggested by Ludwig, regard these three families as forming one of the two great branches of the family tree of the holothurians.

While the Synaptidæ retain some primitive characteristics, as, for example, hermaphroditism, they are in many respects highly specialized forms, particularly as regards sense organs. Otocysts, containing a single vesiculated cell, and sensory papillæ upon the surface of the body and the abaxial surface of the tentacles are described in *S. vivipara.* The ganglia found by Cuénot[1] at the base of these papillæ in *S. inhaerens* O. F. Müller have been observed also in *S. vivipara.* The structure of similar ganglia in *S. girardii* Pourtalès and *S. roseola* Verr. of our own coast has lately been investigated with methylene blue by the present writer.

When the larva has still only ten tentacles a pair of "eyes" appear in the connective tissue at the base of each tentacle, and later, when the last two accessory tentacles appear, one in each lateral dorsal interradius, another pair of eyes is formed at the base of each of them. A knob-shaped protuberance grows out from the side of each tentacular nerve, where it arises from the nerve ring, into the connective tissue, and becomes covered with a layer of mesenchyme cells. This mesenchymatous covering in the adult consists of a "rather horny" layer of light brown color, containing scattered nuclei; it is continuous with a thin mesoderm layer which is said to surround all the

[1] L. Cuénot, Études morphologiques sur les Echinodermes. *Archives de Biol.*, tome xi, pp. 313–680, Pl. XXIV–XXXI. 1891.

nerves; this covering becomes transformed into a thick, pigmented, lens-like structure. The "eye" proper consists of vacuolated cells of a prismatic shape; each is swollen at the free end and tapers at the other extremity, at which it is continuous with a nerve fiber.

It is remarkable that in *S. vivipara* no true sensory buds, the cup-shaped structures that are found in many Synaptidæ attached to the axial surface of the base of the tentacles, were discovered.

Nerves which supply the œsophagus and mouth region in *S. vivipara* are described. Similar nerves in *Caudina arenata*, ten in all, were investigated by the present writer.[1] These nerves have been observed in several other holothurians not noted by Dr. Clark, and in view of their widespread occurrence it is not improbable that they may yet be found in most, if not in all, holothurians.

In our brief consideration of this interesting holothurian we have noted the degeneration of the genital duct, the thinness of the walls of the reproductive tubules, and the apertures through the wall of the rectum, — all adaptations parallel with a most peculiar manner of protecting the young; we have considered the marked degeneration of the water vascular system, no radial canals being found even in the larva, and the significant fact that the tentacles in part spring from radial outgrowths of the hydrocoel, as in Cucumaria and Caudina; and, finally, allusion has been made to some features of certain sense organs which are found not only in *Synapta vivipara*, but also in other Synaptidæ.

JOHN H. GEROULD.

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Shufeldt's Chapters on Natural History.[2] — The first thing which strikes one in opening this volume is the beauty of many of the illustrations, most of them half-tone reproductions of photographs direct from nature. Dr. Shufeldt has long advocated this method, and the results here presented fully justify his contention. There is a life to these illustrations which is lacking from even the best of products of pencil and brush; the artist represents the animal as he thinks it ought to look; the camera represents the animal itself. To us the best of the illustrations are that of the common swift (Sceleporus), those of the green snake and king snake (*Cyclophis vernalis*

[1] J. H. Gerould, The Anatomy and Histology of Caudina arenata (Gould). *Proc. Bost. Soc. Nat. Hist.*, vol. xxvii, pp. 7–74, 8 pl. 1896. Also *Bull. Mus. Comp. Zool.*, vol. xxix, pp. 121–190, 8 pl.

[2] *Chapters on the Natural History of the United States.* By R. W. Shufeldt, M.D. Studer Brothers, New York, 1897. 8°, pp. 472 [+ 8].

and *Ophiobolus rhombomaculutus*), and the first of the cedar bird. The text tells us of the trials necessary in order to get such results, and every amateur in photography knows that not every plate exposed can produce negatives equal to even the poorest in the volume. With such illustrations as a rule, it is a pity that there should be others in the volume, drawn by the author, of a decidedly lower standard.

Judging from the statements made in the first chapter, the text is intended primarily for younger readers, but the author has not been very successful in writing up (or down) to his constituency. In places he explains at some length points which every boy knows, while in others he assumes a knowledge on their part of facts which of course are familiar to those who, like the author, have spent years in scientific study. Then the book in many places sets a bad example to the young in the way of faulty English, while the proof reading is poor, battered letters, wrong fonts, and bad punctuation and capitalization disfiguring the otherwise fine pages. Again, there are many statements open to question. Thus, on page 146, speaking of the turtles, our author says: "It is with the Batrachia only that they can claim any affinity, as is shown by their structure. From all other existing reptiles they are clearly distinguished by the hard osseous shell that encases their bodies. . . ." On page 74 the statement is made that only two specimens of the rare shark Chlamydoselachus have come into the hands of science. Garman had one; Günther had three specimens when preparing his account in the "Challenger" report. In 1890 a specimen was found off the Madeira Islands, and in 1896 one was found off northern Norway. Besides these, the Japanese have obtained several additional specimens, and as we write we find specimens quoted at about sixty dollars in the catalogues of dealers. Among minor faults, we notice the use of the name Muraenopsis, although years ago Ryder pointed out that this genus had no validity. Fig. 106 should have been credited to Elliott. The trinomial nomenclature introduced here and there is unnecessary, and in the abbreviated form in which it occasionally appears (*e.g.*, *L. g. getulus*) it will be more than confusing to the beginner.

Aside from such shortcomings as those instanced, the volume has the materials for a good book. There is a demand for books which will interest the young in just those lines of study which are sorely neglected in our ordinary text-books. The old-time naturalist had his faults, but he had also his merits, and it is greatly to be regretted

that he is passing away. Books built on lines like those which Dr. Shufeldt follows will tend to render the time of his total extermination far distant, and, in case a second edition of this work is called for, we hope that it will be developed largely on the model shown in the chapter on bats, to our mind the best chapter in the whole work. It would be well in a second edition to omit the final chapter on museums, which, as it now stands, has no *raison d'être*.

Origin of the Cleavage Centrosomes. — Boveri, in 1887, was the first to prove that the centrosome which gives rise to the centrosomes of the first cleavage spindle is brought into the egg by the spermatozoön. This observation, made on the egg of Ascaris, led to the formulation of the following conclusion by Boveri: "The ripe egg possesses all of the organs and qualities necessary for division excepting the centrosome, by which division is initiated. The spermatozoön, on the other hand, is provided with a centrosome, but lacks the substance in which this organ of division may exert its activity. Through the union of the two cells in fertilization all of the essential organs necessary for division are brought together; the egg now contains a centrosome which by its own division leads the way in the embryonic development."[1]

Additional evidence was soon furnished by Vejdovsky, who, in the case of Rhynchelmis, followed the disappearance of the egg centrosome, a thing which Boveri had not actually done. Fol, however, in 1891, described the remarkable process in the echinoderm egg, which he called the "Quadrille of Centers," and maintained that the egg centrosome and sperm centrosome divide, each into two, the daughter centrosomes then conjugating, a maternal with a paternal one, to form the two centrosomes of the first cleavage spindle. His paper was generally accepted, in spite of the earlier work on the subject, and was confirmed by the results of Guignard, Conklin, Blanc, Van der Stricht, and Schaffner. Belief in the existence of the "quadrille" was destined to be dissipated in the light of later research, and a score of investigators have definitely proved its mythical character; among these may be mentioned Fick, Wilson and Mathews, Mead, Boveri, Hill, Rückert, Reinke, Kostanecki and Wierzejski, Sobotta, and several others. A return has, therefore, been made to Boveri's original contention that the cleavage centrosomes are derived solely from the sperm centrosome, and, as the

[1] *The Cell in Development and Inheritance.* By E. B. Wilson. New York, 1896, pp. 141, 142.

observations extend over a very wide range of forms, the applicability of the view to the whole animal kingdom has been generally accepted.

There has been one discordant account, however, since Wheeler, in 1895, published a preliminary paper[1] in which he maintained that in the case of *Myzostoma glabrum* the egg centrosome persists and divides to form the cleavage centrosomes. This observation, coming from such an able investigator and being supported by the unqualified statement that no trace of centrosome or archoplasm could be detected in connection with the sperm nucleus, carried with it great weight; but, as it stood a solitary exception to the recent work on the subject, criticism was for the greater part suspended until a more detailed description had appeared. His completed paper[2] has recently been published, giving additional figures and stronger evidence in support of his position. One would have accepted his results unhesitatingly, had it not been for the fact that there has since appeared a paper[3] by Kostanecki, who has worked on the eggs of the same species, *M. glabrum*, and arrived at conclusions absolutely at variance with Wheeler's. This investigator is unable to find any persisting egg centrosome, which, he states, utterly disappears after the extrusion of the second polar body, but he does see a small, clear, archoplasmic area lying close to the side of the sperm nucleus, and containing one or two centrosomes and later distinct radiations. This sperm aster by division forms the amphiaster of the first cleavage, and the author concludes that Myzostoma presents no exception to the view of Boveri. It is unfortunate that Kostanecki had not seen Wheeler's final paper before the publication of his own work, as much of his criticism of the latter's figures in the preliminary note is destroyed by the more detailed description and by new and clearer figures in the later account.

In regard to the maturation processes, the two authors are in agreement on essential points, but it might be mentioned that Wheeler was only able to find a "Zwischenkörper" in the second polar mitosis, while Kostanecki states that he has seen it in the first as well, although he does not figure it.

After the formation of the polar bodies and the two re-formed vesicular pronuclei have begun to approach each other, there is a period when neither Wheeler nor Kostanecki has discovered in many

[1] *Journ. Morph.*, vol. x, No. 1, 1895.
[2] *Archiv. de Biol.*, tome xv, fas. 1. 1897.
[3] *Archiv. f. mikr. Anat.*, Bd. li, Heft 3. 1898.

of Mendota is *D. oregonensis*, while that of Green Lake is *D. minutus*, a species of very different habits. It should be noted, too, that the Diaptomi are especially susceptible to the influences of the environment, and we must expect the different species to have their own peculiarities.

He enumerates eight factors which determine vertical distribution, *viz.*: (1) food, (2) temperature, (3) condition of water in regard to dissolved oxygen and other substances, (4) light, (5) wind, (6) gravity, (7) the age of members of any given species, (8) specific peculiarities.

Of these factors, the third is one of great importance, which has received very little attention from preceding authors. Professor Birge states that he is unable to state whether the lack of life in the lower waters of Mendota is due to a lack of oxygen or to a large amount of the products of decomposition. It has seemed to the reviewer that it was very probable that the products of decomposition have very much to do with the lack of life in many lakes, for, in an examination of a number of the Wisconsin lakes during the last summer, it was noticed that the deep lakes of small area had a large amount of organic matter on the bottom and almost an entire lack of animal life, while in the larger lakes with less organic matter there was a considerable abundance of animals. The other factors are discussed with considerable fullness. It is shown that gravity has a marked influence on the vertical position of crustacea, as it is only by considerable effort that they maintain their vertical position, and that, as they grow old or are enfeebled for any cause, they gradually fall to lower levels. Under seven it is shown that the young crustacea appear in greater numbers near the surface. The young of the copepods form an exception, however, for they appear in the greatest numbers near the thermocline.

In conclusion, the reviewer must again express his regret that it is impossible to do justice to the paper within the limits of ordinary review, and considers that he has done as well as could be expected if he has succeeded in making evident the value of the investigation.

BOTANY.

Lessons with Plants.[1]— In recent years there has been a great multiplication of books designed to render the study of botany attrac-

[1] *Lessons with Plants: Suggestions for Seeing and Interpreting Some of the Common Forms of Vegetation.* By L. H. Bailey. With delineations from nature

tive to the general reader. Albeit some of these have contained a good many questionable statements, they have all ministered more or less directly to an increasing popular demand for simple, non-technical presentations of scientific themes. During the same time there have been many attempts to prepare text-books of botany for common schools and grammar and high schools, the aim of each being to combine simplicity with exactness of statement. Some of these books have been very good, but none of them have occupied quite the field of the one before us.

This book occupies a sort of middle ground. It is not strictly a botany, at least not in the old technical sense, but rather a delightful book about plants, — a series of nature studies designed to interest all sorts of people, old and young, teachers, preachers, laymen, and students. Mothers who wish to teach their children something about plants and do not know how to begin will find this book very useful. The same may be said of a large class of teachers in our public schools. At the same time, it will prove a pleasant companion for persons who are neither parents, teachers, nor botanists, but who have a leisure hour now and then for rambles and wish to know something about the plants they meet.

The first sentence of the introduction sets the pace for the whole book: "Plants are among the most informal of objects, but botany is popularly understood to be one of the most formal of the natural sciences. This is only another way of saying that plant study is not always taught by a natural method."

The book is exceedingly attractive in appearance and a perusal of its contents in no way lessens the first impression. It is interesting from beginning to end, even to a professional botanist, who might be pardoned some weariness over details of things long familiar. The aim of the book is to cultivate the reader's faculty for observation and his ability to reason correctly on what he has seen. Some of its suggestive statements will bear quotation: "The lesson to be derived from this discussion is not what particular interpretation has been placed upon certain facts, but that there is endless variety, and that every fact and phenomenon must be investigated for itself." Again: "In making such studies as those recommended in the last paragraph, both teacher and pupil should consider that mere identification is not the end to be sought. It is always a satisfaction to know the names

by W. S. Holdsworth, Assistant Professor of Drawing in the Agricultural College of Michigan. Macmillan, New York, 1898. xxxi + 491 pp., with 446 illustrations.

of plants, but the important results, from the educational point of view, are the awakening of sympathy with natural objects, the sharpening of the powers of observation, and the strengthening of the faculty of reasoning from the object to laws and principles." And once more: "The collecting of natural objects is one of the delights of youth. Its interest lies not only in the securing of the objects themselves, but it appeals to the desire for adventure and exploration. Botanizing should be encouraged; yet there are cautions to be observed. The herbarium should be a means, not an end. To have collected and mounted a hundred plants is no merit; but to have collected ten plants which represent some theme or problem is eminently useful. Schools usually require that the pupils make an herbarium of a given number of specimens, but this is scarcely worth the effort. Let the teacher set each collector a problem. One pupil may make an herbarium representing all the plants of a given swale, or fence-row, or garden; another may endeavor to show all the forms or variations of the dandelion, pigweed, apple tree, timothy, or red clover; another may collect all the plants on his father's farm, or all the weeds in a given field; another may present an herbarium showing all the forest trees or all the kinds of fruit trees of the neighborhood, and so on."

The style of the book is very clear and often remarkably vivid. Occasionally a whole landscape is crowded into a line or two, as in the following: "Most persons are familiar with the flowering dogwood, the small twisted-grained tree which hangs its pink-white sprays against the woodlands in early spring."

All of the illustrations are original, many are excellent, and some are very unique and attractive, *e.g.*, the group of dandelions, the mayflower, the hepaticas, the turnip field showing "a battle for life." The book has a full table of contents, a register of illustrations (to which most of the Latin names are relegated), a glossary, and a good index. The body of the work is divided into parts, chapters, and numbered paragraphs, so as to make it very convenient for use. The introduction tells how the book may be used and how it came to be written. The first part of the text proper is devoted to studies of twigs and buds. This is followed by studies of leaves and foliage, studies of flowers, studies of fructification, studies of the propagation of plants, studies of the behavior and habits of plants, studies of the kinds of plants, and an appendix containing suggestions and reviews. It is not forgotten that country schoolhouses are usually forlorn places, and some pages and several pictures are devoted

to showing how the grounds may be made more attractive at slight expense.

Throughout the book the fact is kept constantly before the mind that plants are not fixed and unchangeable objects, but very plastic, gradually changing with changing conditions. Perhaps no text-book ever written is more successful in this respect. "The present forms of vegetation, then, are the tips of the branches of the tree of life. Therefore, the 'missing links' are to be sought behind, not between: they are ancestors, not intermediates." Again: "We really cannot understand plants by interpreting them solely upon their present or obvious characters; the reasons for the appearing of given attributes should be sought in the genealogy, not in the present-time characteristics. It is possible that many of these structures which seem to us to have arisen for the purpose of dispersing the seeds may have originated as incidental or correlative structures, and that it merely so happens that they serve a special but incidental purpose in disseminating the plant. If we once assume that every feature of a plant is adapted to some specific purpose, and that it has arisen by means of the effort of the plant to adapt itself to such purpose, we are apt to find adaptations where there are none. We are really throwing our own thoughts and feelings into the phenomena; and we are developing a superficial method of looking at nature."

Occasionally one notices such slips as are inseparable from first editions, but the errors are remarkably few and of such a nature as to admit of easy correction in the next edition, which we understand is already in preparation. Undoubtedly, the book will open the eyes of a great many people to the delights of meadows and woodlands, and also to the many interesting things that may be found even in a window garden or in the smallest dooryard. It deserves to have a very wide reading, and it is not too much to wish that it might find its way into the hands of a majority of the teachers in our common schools.

ERWIN F. SMITH.

Morphology and Development of Astasia asterospora and Bacillus tumescens. — In recent years several well-known writers, like Bütschli, Fischer, and Migula, have given us their views on the bacterium cell. Since these writers do not agree as to the structure and nature of all the parts, Arthur Meyer[1] has made a careful study

[1] *Studien über die Morphologie und Entwickelungsgeschichte der Bacterien, ausgeführt an Astasia asterospora A. M. und Bacillus tumescens Zopf.* Flora, **84**: pp. 186–248, pl. 6.

of the life history and morphology of *Astasia asterospora* A. M. and, incidentally, *Bacillus tumescens* Zopf. The paper, in addition to its value as a morphological study, contains many interesting details on methods of staining to differentiate different parts and clearly bring out the structure of the spores, nucleus, vacuoles, and mucilage.

The organism was obtained from boiled carrot and isolated by heating the spores to 90° C. for three minutes. On sterilized carrots, a gray, lustrous, gelatinous mass grows along the line of inoculation, and in five days spreads over the whole surface, with numerous gas bubbles. Other culture media used were as follows: peptone cane sugar solution, asparagine solution, peptone meat extract. In cane sugar solution, the organism produced 25–60 per cent of carbon dioxide, the remainder being a combustible gas, chiefly hydrogen. In a normal nutrient solution, the medium became cloudy in fourteen to eighteen hours. During this period the rods are actively motile (period 1). Motility ceases in twenty-four hours, small masses of bacteria occur, and some gas is formed. The former increase in size, becoming large and flaky, and rise to the surface with the contained gas. In fifty hours gas development has ceased entirely. The end of the period occurs in forty-eight hours (period 2). In forty-eight hours the gelatinous flakes drop to the bottom of the flask, and spores are abundant (period 3). In sixty-four hours isolated ripe spores occur (period 4).

The author determined that it does not produce a diastatic ferment capable of dissolving starch, nor one that is capable of reducing cane sugar, but in all probability an enzyme is formed which acts upon cellulose, since the middle lamella of the cell wall of carrot is dissolved. It is also an acid-producing organism; the amount is greater in normal nutrient solution than when grown in asparagine solution.

The morphology and development of Astasia may be summarized as follows: The spore germinates in a normal nutrient solution, when kept at 30° C., in about six hours. The rod coming from the spore is at once motile; by repeated subdivisions other rods are formed. In the course of twelve hours single motile rods cease to move, and the development of mucilage proceeds. One may also notice that motile masses move through the medium, and these approach a mass and leave it again. This is kept up till the "swarmer" becomes inactive. In this way round colonies are formed and with the contained gas rise to the surface, where they collect as mucilaginous flakes. Generally the Astasia occurs as a

single rod. Rarely are the rods placed end to end, forming a thread imbedded in mucilage. Mucilage is not formed by the transformation of the cell wall. Meyer further demonstrates that an abundance of mucilage is formed between the two rods in the process of cell division, but is difficult to demonstrate during the early stages. In the motile stages it occurs only between the two rods, but in the resting stage mucilage rapidly surrounds the whole organism. It may be noted, also, that a protoplasmic band connects the two rods in Astasia and some other species examined. It is probable that protoplasmic connection will be found in bacteria where rods form chains, or in motile forms which consist of several rods. The bunched flagella are lateral, and occur singly or a pair near the end, and occasionally a third bunch below. The third bunch, in most cases, occurs before division. Vacuoles may be made out in stained as well as unstained preparations, and these are axillary, much like those of Eumycetes. These differ in form as well as number. The Astasia vacuole was compared with that of Hypomyces, in which glycogen was found. The vacuole of dried Astasia preparations stains readily, the peripheral portion more intensely than the cytoplasm. It is to be expected that the vacuoles of bacteria should often contain concentrated reserve material.

The bacterial protoplast has some further points of similarity with Eumycetes. It has one or more nuclei in the cell, but not Bütschli's nucleus. Bütschli considers that a "Centralkörper" is the main part of the protoplast, and that cytoplasm is reduced to a minimum. Meyer's nucleus is a much smaller body. With staining reagents it behaves like the nucleus of fungi. In cell division the cytoplasm contracts, and a nucleus passes into each part. In one hour a new cell is formed, each rod containing a nucleus. The nucleus is not connected with the formation of the cell wall. *Bacillus tumescens* forms its spores in the same way that Astasia does. One-half of the cytoplasm of the sporangium becomes clearer, the other half granular. In a short time the somewhat more refractive fertile cytoplasm of the sporangium contains a nucleus, and the whole is separated from the homogeneous plasma by a delicate line. The young spore refracts light strongly. A wall forms about it, and at maturity it is provided with two walls. In Astasia the outer wall (extine) is provided with projections and the intine is smooth. A strongly refractive rod may also be observed in the interior. The method of spore formation in these species may be compared with that taking place in Ascomycetes. Astasia, however, never branches,

but perhaps true branching occurs in some species closely related to this organism. Motile masses are never produced by the Ascomycetes, a difference that constitutes a valid point of separation. Meyer discusses the relationship of Schizomycetes to this group, and proposes the following classification of the

BACTERIACEÆ.

BACTERIEÆ. Cells motionless. *Bacterium.*
BACILLEÆ. Flagella arising from the whole surface. *Bacillus.*
PSEUDOMONATEÆ. Flagella polar.
(*a*) Normally with a single flagellum. *Bactrineum.*
(*b*) Normally with more than one flagellum. *Bactrilleum.*
ASTASIEÆ. Flagella in groups, lateral.
Flagella in one or two groups, one-celled rods. *Astasia.*

L. H. PAMMEL.

Brown Rot of Cruciferous Plants. — Erwin F. Smith, who has made an exhaustive and careful study,[1] concludes that *Pseudomonas campestris* is responsible for the brown rot of cabbage and other cruciferous plants. There certainly seems to be no doubt that the organism described somewhat briefly by the writer several years ago is identical with that described by Smith. It produces a distinct browning in the bundles, the bacteria having a fondness for the alkaline sap of the bundles and little attraction for the acid parenchyma. Infections were obtained by needle punctures, by means of slugs and insect larvæ, and through the water pores situated on the teeth of the leaves. Infections through ordinary stomata were not obtained; the waxy bloom on the cabbage leaf protects the plant. It is probable that a majority of the natural infections in the field take place above ground, the disease being transmitted from diseased to healthy plants and from one part of a plant to another, as the result of the visits of insects and other small animals. The organism grows well in feebly alkaline beef broth. Gelatin is slowly liquefied. In addition to these media, Smith cultivated it on cabbage broth, litmus cabbage broth, agar, potato, carrot, beet, onion slices, orange segments, cocoanut flesh, etc. In cruciferous substrata it grew promptly and with great vigor, except on the horse-radish, where the growth at first was slow. On steamed cauliflower the organism was brightest, approximately lemon yellow or light cadmium; it was

[1] Erwin F. Smith, Pseudomonas campestris (Pammel): The Cause of a Brown Rot in Cruciferous Plants. *Centralb. f. Bakt. u. Parasitenk.*, Abt. ii, Bd. iii, pp. 284–291, 408–415, 478–486, Pl. VI. 1897.

dullest on the steamed turnip, where there was also a marked production of the brown pigment. The organism was also grown in fermentation tubes using the various kinds of sugars. It is not an acid or gas producer. A brief summary of characters is given at the end of the paper. The organism is closely related to Wakker's *Bacterium hyacinthi*, from which it differs chiefly in its pathogenic properties. This paper is an important contribution to our knowledge of bacterial diseases of plants. Great care was observed in details of making media, and the manner in which the infection experiments were conducted should be highly commended.

In a second paper on the same subject [1] Dr. Smith deals largely with methods of prevention, giving the result of field studies made in 1897. Nine-tenths of the infections are through water pores. Infections by means of the gnawings of insects were also observed. The disease has been successfully inoculated into the black mustard, and is common in some places on charlock. No evidence has been obtained to show that it is transmitted by seed. A contaminated soil is the most frequent source of infection. The observations here recorded leave little room to doubt that the organism lives over winter in the soil, that it is often transplanted from contaminated soil to healthy fields in diseased seedlings, and that the preparation of healthy seed beds, *i.e.*, on soil free from this organism, is one of the most important preventive measures. Of course, rotation of crops would also be an effective remedy.

L. H. PAMMEL.

A New Laboratory Manual. — To the many laboratory manuals is added a new one in the field of botany,[2] which is intended to give the student a general view of the subject and at the same time to lay a foundation upon which more advanced studies may be built. The author suggests that the rather extended scope of the book need not prevent its use for briefer courses, since by judicious selection certain parts only may be used where the entire field cannot be covered. One hundred and ninety-one illustrations add to the attractiveness of the book, and in the main they are well selected from good sources. Though the illustration of a laboratory guide is a device for conveying information rather than promoting independent investigation, it is by no means certain that it is a reprehensible practice when, as is

[1] The Black Rot of the Cabbage. *Farmers' Bulletin*, No. 68. U. S. Dep. of Agric., Washington, D. C., Jan. 8, 1898.

[2] C. H. Clark, *A Laboratory Manual in Practical Botany*. New York, American Book Company (1898), 271 pp.

the case in most colleges, a very small percentage only of the students of science are likely ever to have the opportunity to devote their lives to research. T.

A Guide in Vegetable Physiology. — Professor Arthur of Purdue University has issued in pamphlet form an outline for thirty-five laboratory exercises in vegetable physiology,[1] which are intended to guide the student in manipulation while avoiding the provision of information as to the purpose of the experiments or the deductions to be drawn from them.

Digestion of the Albumen of the Date. — M. Leclerc du Sablon, in the *Revue Générale de Botanique* for Nov. 15, 1897, publishes a paper on the digestion of the "albumen" of the date, in which it is shown that not only is this albumen incapable of digesting itself, but that the diastases secreted by the cotyledon, which attack the cellulose, do not penetrate into the albumen, their action appearing only in the region of contact between the cotyledon and the albumen, only the enzyme which leads to the production of fatty acid passing from the cotyledon into the albumen, where it begins the digestion of the fatty reserves.

Experiments with Etiolated Leaves. — In a paper published in No. 107 of the *Revue Générale de Botanique*, Palladine shows that when etiolated leaves free from carbohydrates are placed on the surface of various solutions, saccharose, raffinose, glucose, fructose, maltose, glycerine, galactose, lactose, and dextrine favor the formation in them of chlorophyll, while inulin and tyrosin produce no effect, and mannite, dulcite, asparagine, alcohol, and some other substances either retard or completely prevent the formation of the pigment.

Life History of Ranunculus. — To the *Botanical Gazette* for February, Prof. John M. Coulter contributes an addition to the life history of Ranunculus, embodying the results of the study of a number of research students at the University of Chicago. The results appear to justify the conclusion that while it is comparatively easy to obtain a definite sequence in the development of structures when the facts are few, definite sequences seem to disappear as facts multiply; a conclusion which may be paralleled in nearly or quite all

[1] J. C. Arthur, *Laboratory Exercises in Vegetable Physiology*. Lafayette, Ind., 1897. Kimmell & Herbert.

lines of investigation, and one which speaks strongly against the too frequent custom of basing broad generalizations on isolated and unverified observations.

Food Plants of Scale Insects. — Though sometimes misleading, lists of the host plants of parasitic fungi or of the food plants of vegetable-feeding insects are always helpful when properly used; and a list of the food plants of scale insects, by T. D. A. Cockerel, in volume xix of the *Proceedings of the United States National Museum*, will be acceptable to students of this group. The author states that it is to be understood that the plants given as hosts have been infested in many cases only since they have been cultivated, and suggests that it would be desirable to distinguish in every case between the endogenetic and exogenetic Coccids on a plant, and also between those exogenetic in a state of nature and those only so in cultivation.

Timber Pines. — The timber pines of the Southern United States form the subject of an important contribution from the Division of Forestry of the Department of Agriculture.[1] Though a revised edition of an earlier series of monographs, the present publication appears with almost the value of a new work. In it *Pinus palustris*, *P. heterophylla*, *P. echinata*, *P. tæda*, and *P. glabra* are quite fully considered, from the standpoint of forestry and mechanics, as well as that of botany. To the teacher of economic botany such excellent illustrations as those of Plate VIII, showing the method of "turpentine orcharding in Louisiana," are next in value to an actual field demonstration. T.

New England Botanical Club. — The New England Botanical Club, an association of gentlemen interested in the flora of New England, which holds monthly meetings in Boston and has begun the formation of a New England herbarium, has recently issued a tastefully prepared pamphlet containing its constitution, with a list of its officers and members. Thirty-seven resident and twenty-four non-resident members are enrolled.

Botanical Garden in Dahlem. — The plans for the new botanical garden in Dahlem, near Berlin, the distance of which from the teaching departments of the great Berlin University is lamented by

[1] *The Timber Pines of the Southern United States.* By Charles Mohr, Ph.D. Together with a discussion of the structure of their wood, by Filibert Roth. *Bulletin No. 13* (revised edition), *U. S. Department of Agriculture, Division of Forestry.* Washington, 1897. 176 pp., 27 pl., 4°.

those whose duties confine them more closely to the University, have been quite fully outlined by Dr. Engler and his associates in recent numbers of *Gartenflora*. The concluding article, in the issue for January 15, contains a small map illustrating the general features of the planting and the location of the buildings.

Botanical Notes. — A further contribution to the systematic value of seed anatomy is published by Pritzel, in Heft 3 of *Engler's Botanische Jahrbücher* for 1897, in which the endosperm is discussed in detail for representatives of a considerable number of genera, especially of the Parietales.

The January number of *Forstlich-Naturwissenschaftliche Zeitschrift* contains a description, by Tubeuf, of an aberrant form of our white pine, which is descriptively called *Pinus strobus*, forma *monophylla*.

In the *Berichte der bayerischen botanischen Gesellschaft*, Bd. v, 1897, Andreas Allescher describes a considerable number of new "fungi imperfecti," which, although the types are of Bavarian collection, in many cases occur on hosts that grow also in the United States, so that students of this class of form species need to make note of them.

The double root cap of Tropæolum, described by Flahault in 1878, forms the subject of a communication to the French Academy by M. Brunotte, published in the *Comptes Rendus* of January 17. It is held that the supernumerary sheath originates from the proliferation of the cells of the suspensor.

The study of the hibernacula of plants has received an important extension in an examination of the reproductive organs of a number of species of Pteridophytes and Phanerogams, the results of which are published by Mr. Chamberlain in the *Botanical Gazette* for February, under the title "Winter Characters of Certain Sporangia."

A careful study of the ecological phases of a Scandinavian sand flora is contributed by Erikson to the botanical section of volume xxii of the *Transactions of the Royal Swedish Academy*.

The *Annals of Scottish Natural History* for January contains an article on the flora of Tiree, by Macvicar, and one on the topographical botany of Scotland, by Professor Trail, as an addition to the well-known *Topographical Botany* of the late H. C. Watson.

Professor Spegazzini contributes to the fifth volume of the *Anales del Museo Nacional de Buenos Aires*, for 1896–97, just received, a paper on Fuegian plants collected in 1882, in which eighteen species and one variety — all Phanerogams — are described as new. Five of the species are figured.

Students of South American botany will be interested in the Xyrideæ and Burmanniaceæ (by Malme) and Oxalidaceæ (by Frederikson) of Regnell's first expedition, contained in volume xxii of the *Transactions of the Royal Swedish Academy* of Stockholm.

The occurrence of fossil remains of Brasenia in Russia and Denmark forms the subject of a paper by Gunnar Andersson in the botanical section of the appendix to volume xxii of the *Transactions of the Royal Swedish Academy* of Stockholm, issued in 1897. Two plates illustrate the structure of recent and fossil specimens, the former from Japan and the United States.

Dr. Ernst Huth, whose death in August last cut short a promising botanical career, had prepared a paper on the Ranunculaceæ of Japan, with especial reference to the species collected by Father Faurie between 1885 and 1896, which is published in the *Bulletin of the Boissier Herbarium* for December, 1897.

The Bavarian Botanical Society, which has its home in Munich, is publishing in its *Berichte* a preliminary flora of Bavaria, in which full ordinal descriptions, keys to genera, full generic descriptions, keys to species in the larger genera, and detailed specific descriptions are given. In many cases the geographical range of the several species of a genus is indicated on reduced maps of the country, which, for the more ready contrast of related species, are printed in pairs in the text. Thus far, the flora reaches Dentaria, in the Cruciferæ.

A somewhat similarly treated flora of the neighborhood of Nuremberg and Erlangen, by A. F. Schwarz, which is being issued in parts by the Natural History Society of Nuremberg, reaches the Rutaceæ, in the tenth volume of the *Abhandlungen* of the Society.

Acalypha virginica, a common North American plant which has become established in Italy, forms the subject of a note by Traverso in *Malpighia* for 1897. It appears that in the vicinity of Pavia, in addition to this species, *Azolla caroliniana*, *Elodea canadensis*, *Commelina virginica*, *Oxybaphus nyctagineus*, and *Solidago serotina*, all pertaining to our flora, have rather recently become established.

Euphrasia canadensis, a supposed new species from the vicinity of Quebec, is described and figured by Frederick Townsend in the *Journal of Botany* for January.

Frederick N. Williams publishes in the January number of the *Journal of Botany* a short article on primary characters in Cerastium, and characterizes in accordance with his views Dichodon, Strephodon, and Orthodon as subgenera.

Mr. C. A. Purpus, who for some time has been active in introducing the choicer species of our Western and Pacific coast vegetation into European gardens, contributes to the *Mitteilungen der Deutschen Dendrologischen Gesellschaft* for 1897 an account of his travels in the southern Sierras of California and the Argus and Madurango ranges.

Eriogonum, one of the more puzzling genera of Apetalæ, is enriched by the addition of twenty-two new species, in a paper by Dr. Small, published in the *Bulletin of the Torrey Botanical Club* for January. In the same article, *Oxytheca parishii* Parry is made the type of a new genus, Acanthoscyphus.

The tree opuntias of the United States form the subject of an interesting short article in the February number of the *Botanical Gazette*, by Professor Toumey, whose opportunities for the study and cultivation of cacti, in Arizona, are unrivaled.

A paper on some biographical difficulties in botany, — some of which apparently might be escaped by carrying the application of the principle of priority to Tournefort's work, instead of stopping with the species Plantarum of Linnæus — read before the Botanical Society of America in Toronto last summer, by Prof. E. L. Greene, has been reprinted from volume iv of the *Catholic University Bulletin*, of Washington.

M. Cardot, in the *Bulletin de la Société d'Histoire Naturelle d'Autun* for 1897, publishes a Répertoire Sphagnologique, an alphabetical catalogue of all known species and varieties of Sphagnum, with indication of synonymy, bibliography, and geographical distribution. The pamphlet, which is separately paged, contains 200 pages, octavo.

The Botanical laboratory of the University of Siena has begun the publication of a new journal,[1] the first fascicle of which, for January, 1898, contains a report on the botanical garden and museum for the scholastic year 1896–97, and a number of scientific papers, chiefly on fungi, — a group with which Italian botanists are very largely occupied.

PALEONTOLOGY.

Pleistocene Flora. — For a number of years the Pleistocene flora of Canada has formed the subject of special investigation, chiefly by Sir Wm. Dawson and Professor Penhallow, of Montreal, and Prof.

[1] *Bull. lab. bot. R. Univ. Siena.* Redatto del Dott. Fl. Tassi.

A. P. Coleman, of Toronto. The results reached were of such interest and scientific importance that the British Association at its last meeting at Toronto appointed a special committee, consisting of Sir J. W. Dawson, chairman, Prof. A. P. Coleman, secretary, Prof. D. P. Penhallow, Dr. H. M. Ami, and Mr. G. W. Lamplugh, "to further investigate the fauna and flora of the Pleistocene beds in Canada," and for this purpose made a grant of £20.

For several months past the work of this committee has been actively prosecuted under the immediate direction of Professor Coleman. The results so far reached afford a valuable extension of our previous knowledge respecting the vegetation of that period, and confirm former conclusions as to climatic conditions.

In his last summary of the Pleistocene flora[1] Professor Penhallow discusses the character of the vegetation observed in deposits of five principal localities, — Moose River, Montreal, Green's Creek and Besserer's Wharf near Ottawa, Scarboro Heights near Toronto, and the Don Valley in the immediate neighborhood of Toronto, from which places sixty-three species of plants have been obtained. All of the plants are found to be identical with existing species. The results of the investigations now in progress will show important additions to this list.

Considered in relation to climate, the deposits of the Don Valley represent a vegetation of a more southern type than that now existing there, such as at present flourishes in the Middle States. In all the other deposits the vegetation represents similar climatic conditions, and is comparable with that which now flourishes in the same or slightly more northern situations. A comparison of the Scarboro and Don beds by Professor Coleman leads to the conclusion that the former were laid down first; hence the inference that in the vicinity of Toronto the vegetation and the climate were at first comparable with what may be found at the present time from the southern shores of Labrador through the region of the Gulf of St. Lawrence and the Province of Quebec; that at a subsequent period the climate became warmer, with the introduction of more southern types of plants, such as the osage orange, and that, finally, another change brought about a partial return to the original conditions, with the development of the climate and flora as at present known.

One of the most interesting features of the material derived from these beds is the very perfect state of preservation in which much of

[1] Contributions to the Pleistocene Flora of Canada. *Trans. R. Soc. Can.*, Ser. 2, 1897. II. iv. 59.

the wood is found. In most cases the wood may be cut with a saw; it softens readily in water, and sections may be cut in the usual manner with as much facility as if taken from an existing tree. In many cases, also, the grain and bark are recognizable, while the interior structure is preserved with great perfection. P.

Polish Palæozoics, by Gürich.[1] — The district described in this memoir is in Southern Poland, mainly in the country between and around Kielce and Opatów. This region has been subjected to considerable oscillation, and the rocks are folded and faulted to a marked degree. The geological section extends from the Cambrian to the top of the Devonian, and the strata reach their greatest development in the Devonian. The Cambrian is represented by a single member, the Silurian by four members, and the Devonian by twenty. The Devonian fauna is especially rich, and represents, together with others, the typical zones of *Rhynchonella caboides*, *Stringocephalus burtini*, and *Goniatites intumescens*, so characteristic of certain faunas and horizons in other parts of the world.

The new genera described comprise Plagiopora, a tabulate coral; Ceratophyllum and Hexagonum, cyathophylloid corals; Spirillopora, a bryozoan; and four genera of ostracoda, Antitomis, Trigonocaris, Polyzygia, and Poliniella.

Interesting studies are made on the amount of crustal oscillation, and the nature of the sediments, whether shore, near shore, off shore, or deep sea. These observations are plotted in curves, on tables of the geological succession for various localities. C. E. B.

[1] Das Palæozoicum Polnischen Mittelgebirge, von Dr. Georg Gürich. *Transactions of the Imperial Mineralogical Society of Russia*, vol. xxx, 1896.

SCIENTIFIC NEWS.

As previously announced in these columns, the Fourth International Congress of Zoology will meet in Cambridge, England, on the 23d of August. Sir W. Flower was elected at the meeting in Leyden to be the president of this Congress, but he has been obliged to resign on account of his health, and in his place the Permanent Committee have chosen the Right Hon. Sir John Lubbock, Bart. We are requested to call attention to the cordial invitation issued by the Reception Committee, which is in part as follows:

"The seat of an ancient University, which counts among its *alumni* distinguished zoologists, from the days of Ray and Willughby to those of Charles Darwin and Francis Balfour, seems to offer a peculiarly fit meeting-place for the Congress on its first visit to the British Islands, and the Reception Committee, including the present representatives of zoological science in Cambridge, hereby offer a cordial welcome to their brethren at home and abroad who may accept this invitation.

"The Reception Committee hope to avail themselves largely of the facilities offered by the several Colleges of Cambridge for the accommodation and entertainment of their visitors, while there is assurance that the more suitable of the public buildings of the University will also be placed at their disposal for the same purposes.

"The International Congress of Physiology is to meet in Cambridge concurrently with that of Zoology, and certain arrangements will be made in common, though there is no intention of uniting the two Congresses — each of which will retain its distinct organization.

"The general arrangements of the Zoological Congress will be made, and from time to time communicated, by the General Committee established at the House of the Zoological Society in London (3, Hanover Square), but the duties of the Reception Committee at Cambridge will be greatly facilitated by the receipt of a reply to this invitation, which they hope may be accepted.

"On the receipt of such an acceptance further details with regard to local arrangements will be duly forwarded. It is hoped that it will be possible to find rooms in the several Colleges for many of the visitors; but it is necessary to point out that the accommodation

afforded within College walls is not suitable for ladies. The Reception Committee will use their best endeavors to find accommodation in lodgings for members who are accompanied by ladies, and it is proposed in due course of time to issue a statement relating to the cost of apartments, railway fares, and other information which will be useful to visitors."

Any zoologist who expects to attend the Congress should address a note to the secretaries of the Reception Committee, The Museums, Cambridge, accepting the invitation, asking for further information in regard to the local arrangements, and stating whether or not he expects to be accompanied by ladies.

Among the recent large gifts which have a scientific interest is one of $1,100,000 by Joseph F. Loubat to the library of Columbia University. The income of this will not be available immediately, as the property is subject to a life annuity of $60,000.

Lafayette College is to rebuild its scientific building, Pardee Hall, the destruction of which was noticed some time ago in these pages.

The Massachusetts Institute of Technology has begun the erection of a new building, one floor of which will be devoted to the biological laboratories, giving them about three times the space that they have in their present cramped quarters. Upon the completion of this building, which is promised in August, the general library of the Institute will be moved into the room now occupied by the biological laboratory.

Pomona College, Pomona, California, is to have a $25,000 science building, the gift of Dr. E. D. Pearsons, of Chicago.

One good appointment is to be placed to the credit of the new U. S. Fish Commissioner, — that of Prof. H. C. Bumpus as scientific director of the station at Woods Holl. During the few years past this aspect of the work of the Fish Commission has steadily degenerated, until last year it was at the lowest ebb. Professor Bumpus brings to the position energy and executive and scientific ability, while the fact that since 1888 he has spent nearly every summer at Woods Holl has given him a familiarity with the locality and the capacities of the station which insures good work. If the Commissioner exercises equally good judgment in his other appointments, he will go far toward disarming criticism.

The circulars for the ninth session of the Biological Laboratory at Cold Spring Harbor, New York, have been issued. Owing to the absence of Professor Conn in Europe, the laboratory this year will be under the direction of Dr. C. B. Davenport, of Harvard, who will be assisted in the instruction by Prof. H. T. Fernald, of State College, Penn., Dr. D. S. Johnson, of Johns Hopkins, Dr. C. P. Sigerfoos, of the University of Minnesota, Prof. W. H. C. Pynchon, of Trinity College, Dr. N. F. Davis, of Bucknell University, Dr. H. R. Linville, of the New York City High School, and Mrs. Davenport. The courses offered this year are: (1) high school zoology, (2) comparative anatomy, (3) invertebrate embryology, (4) cryptogamic botany, (5) phænogamic botany, (6) bacteriology, (7) microscopical methods; while facilities will be afforded those desiring to carry on original research. The laboratory has a good equipment, owns five buildings and a naphtha launch. The tuition is fixed at $20 for one course; additional courses at $5 each. Board costs $4.50 and rooms from $1.50 to $3 per week. Regular class work begins July 6 and continues until August 27. Further information may be obtained from the Director, Dr. C. B. Davenport, Francis Avenue, Cambridge, Mass.

A summer school of biology under the auspices of the University of Illinois will be held at the Illinois Biological Station, on the Illinois River, at Havana, Ill., beginning June 15. The regular session will continue four weeks, but members of classes may prolong their work independently until August 1. The school will be under the general direction of Prof. S. A. Forbes, Dean of the College of Science of the University. An elementary and an advanced course in zoology will be conducted by Prof. Frank Smith and similar courses in botany by Instructor C. F. Hottes. The school will be in the immediate charge of Dr. C. A. Kofoid, superintendent of the Station, who will give his attention to the individual work of advanced students. The Station will be open to a limited number of investigators from June 15 to September 15. The libraries of the State Laboratory of Natural History and of the University and the equipment of the biological laboratories of the University will be available for the school. In order that suitable provision may be made for students and visitors, early application is urged. Final lists of desiderata of literature and apparatus for advanced students and investigators should be sent in before June 1. A fee of $10 per month will be charged. Circulars giving further information will be sent on application to S. A. Forbes, Urbana, Ill.

Prof. Rudolf Leuckart, one of the greatest teachers of zoology the world has known, died at Leipzig, Feb. 7, 1898. He was born at Helmstedt, Braunschweig, Oct. 7, 1823, and received his training in medicine and natural history at the University of Göttingen, where he was largely influenced by the anatomist Prof. Rudolf Wagner, and where, in 1847, in connection with Frey, he prepared the volume on invertebrates in Wagner's *Lehrbuch der Zootomie*. In 1850 he was appointed professor of zoology and comparative anatomy in the University of Giessen, and in 1869 he was called to the chair of zoology at Leipzig. Here his work was more in the line of a teacher than investigator, and no one in recent years has had more influence in training zoologists than he. Among his pupils are to be enumerated Andres, Apstein, Bedot, Berlepsch, Bogandow, Brandt, Bütschli, Burckhardt, Chun, Claus, Fowler, Hatschek, Haswell, Henking, Hurst, Ijima, Korschelt, Kossmann, Kraepelin, de Man, Monticelli, Reichenbach, Salensky, Seeliger, zur Strassen, Sturanay, Tichomirow, Uhlworm, Walther, Weismann, and Zacharias; while of Americans, either by birth or adoption, the following have been his students: Baur, Edwards, Fewkes, Gardiner, C. L. Herrick, Mark, Münsterberg, Murbach, Parker, Patten, Pratt, Stiles, Tyler, Ward, Whitman, and R. R. Wright. For many years Leuckart compiled the record of the literature of the lower invertebrates in the *Archiv für Naturgeschichte*, while his writing upon parasites were numerous and valuable. Later in life, in connection with Chun, he established the elegant series of monographs under the name *Zoologica*, of which twenty-three numbers have so far been issued. Leuckart's greatest generalization was the dismemberment of the Cuverian group of Radiata and the recognition of the Cœlenterata as a distinct group.

The U. S. National Museum has received the collection of fossils and archeological specimens made by the late H. Harris, of Waynesville, Ohio. The fossils number some 13,000 specimens, mostly from the Lower Silurian (Niagara) of Ohio.

Prof. Alfred C. Haddon is planning for a second trip to the regions of Torres Strait. Like his previous expedition, this will be primarily anthropological in character, but biological investigations will also be made. The party will consist of about half a dozen students, and will be fully equipped with the ordinary collecting apparatus and, in addition, with apparatus for psychological investigation and a kinematograph for taking native dances, ceremonies, etc. The expedition will be gone more than a year.

Among the appropriations made by the Berlin Academy of Science are 700 marks to Professor Dahl, of Kiel, for the arrangement of the zoological material collected by him in Ralûm, and 120 marks to Dr. K. Holtermann, in aid of his work upon the fungi of the East Indies.

Mr. W. Whitaker has been elected president of the Geological Society of London.

Recent appointments: Prof. Desider Andyar, director of the gardens in Budapest. — Dr. Otto Appel, assistant for bacteriology in the Hygienic Institute at Würzburg. — Eugen Askenasy, honorary professor of botany in Heidelberg. — R. H. Biffin, demonstrator of botany in the University of Cambridge. — G. L. Bunnell, assistant in zoology in the Sheffield Scientific School of Yale University. — Antonio delle Valle, professor of zoology in the University of Naples.. — Ernst Ebermayer, professor of forestry in the University of Munich. — Dr. G. B. Grassi, of Catania, professor of zoology in the University of Rome. — Dr. Hans Hallier, assistant in the Botanical Museum in Munich. — Jiuta Hara, professor of zoology in the Agricultural College at Sapporo, Japan. — Dr. Ludwig Hecke, docent for vegetable pathology in the Agricultural School in Vienna. — Dr. Heim, docent in vegetable pathology in the Agricultural College in Vienna. — Alexander Henckel, of St. Petersburg, assistant in the Botanical Institute in Odessa. — Dr. Karl Holtermann, docent for botany in the University of Berlin. — Dr. Karl Hürtle, professor of physiology in the University of Breslau. — Masamaru Inaba, professor of zoology in the Higher Normal School at Yamaguchi, Japan. — Dr. J. Joly, professor of geology in Trinity College, Dublin. — F. C. Kempson, demonstrator of anatomy in the University of Cambridge. — Dr. O. Krummacher, docent for physiology in the University of Munich. — Dr. Bengt Lidfors, docent for botany in the University of Lund. — Dr. Lustner, of Jena, assistant in the physiological experiment station at Geisenheim. — Dr. Alexander Mágócsy-Dietz, extraordinary professor of botany in the University of Budapest. — Dr. Maguenne, professor of vegetable physiology in the Museum of Natural History of Paris. — Prof. O. Mattirolot, director of the Botanical Museum and Garden at Florence, Italy. — Dr. Franz Mattouschek, of Prague, professor of botany in the gymnasium at Linz, Austria. — Dr. Lafayette B. Mendel, assistant professor of physiological chemistry in Yale University. — Dr. Mentz, privat docent in physiology in the University of Leipzig. — Dr. Pio Mingazzini, of Rome, professor of zoology, comparative

anatomy, and physiology in the University of Catania, Sicily. — Francesco Saverio Monticelli, professor of zoology, comparative anatomy, and physiology in the University of Modena. — Dr. Joseph Murr, of Linz, professor of botany in the Gymnasium at Trient. — Dr. Asajiro Oka, professor of zoology in the Higher Normal School in Tokyo. — Dr. Polumordinow, docent in histology in the University of Kazan. — Romul Alex Prendel, professor of geology and mineralogy in the University of Odessa. — Dr. J. D. E. Schmeltz, keeper of the Ethnographic Museum at Leiden. — Dr. Alexis E. Smirnow, professor of zoology in the University of Tomsk, Siberia. — W. J. Sollas, professor of geology in the University of Oxford. — Dr. A. Steuer, of Dresden, privat docent in mineralogy in the University of Jena. — Dr. Hermann Triepel, docent for anatomy in the University of Greifswald. — W. G. Van Name, assistant in biology in the Sheffield Scientific School of Yale University. — Rudolf Weber, director of the Forestry Station in Munich. — Dr. Kurt Wolf, docent for bacteriology in the Technical High School in Dresden.

Recent deaths: Edmund J. Baillie, botanist, at Chester, England, aged 47 years. — Georg Berthelin, student of the fossil mollusks of the Paris basin. — Horace W. L. Billington, director of the Botanical Gardens of Old Calabar, Nov. 18, aged 28. — Henry N. Bolander, botanist, at Portland, Oregon, Aug. 28, 1897. — Dr. Hugh Calderwood, demonstrator of anatomy in the University of Edinburgh. — John Finlay, lepidopterist, in London, July 4, 1897. — Oskar Friedrich von Fraas, professor of paleontology in Stuttgart, Nov. 22, aged 73 years. — Dr. E. P. Franz, of London, student of neurology. — Dr. Friedrich Adolf Hoffmann, geologist, in Mexico. — J. B. von Keller, botanist, in Vienna, Nov. 14, 1897. — Dr. Gaetano Licocopoli, assistant professor of botany and assistant in the Botanical Gardens at Naples. — Jean Linden, botanist, in Brussels, Dec. 12, aged 81 years. — The missionary R. Montrouzier, well known as an entomologist and collector, May 16, 1897, in New Caledonia, aged 76 years. — Rev. Charles Samuel Pollock Parish, botanist, Oct. 18, in Somerset, England, aged 75 years. — Dr. Friedrich Oskar Pilling, teacher of botany and author of elementary botanical text-books in Altenburg, Saxony, Nov. 22, aged 73 years. — Dr. Ivan Otto Plekarsky, custodian of the zoological collections of the University of St. Petersburg, aged 30 years. — Heinrich Ribbe, entomologist, at Radebeul, near Dresden, Jan. 19, aged 65 years. — Oskar von Riesenthal, ornithologist, in Berlin, Jan. 21, aged 67 years. — Alexander Thominot, student of reptiles and

fishes, in Paris. — Dr. John Valentin, of the University of Buenos Ayres, while on a geological expedition to Patagonia. — James Windoes, paleontologist, at Chipping Norton, England, aged 58 years. — Morris Young, entomologist, at Paisley, Scotland, aged 76 years. — Count Max Zeppelin, zoologist, in Stuttgart, Dec. 3, aged 41 years. — Gustav Zimmermann, entomologist, at Brüx, Bohemia, Dec. 29, aged 66 years. — Albert Zimmeter, botanist, at Innsbruck, Dec. 15, aged 49 years.

CORRESPONDENCE.

The Mating Habits of Viviparous Fishes. — We are indebted to Professor Eigenmann for the following letter, which is of considerable interest because nothing has been recorded heretofore in regard to the mating habits of the remarkable viviparous fishes of California.

SEATTLE, WASH., Feb. 13, 1897.

MR. CARL H. EIGENMANN:

Dear Sir, — I have just finished reading your article on the "Viviparous Fish of the Pacific Coast," in vol. xii of the *Bulletins of the U. S. Fish Commission*, and was very much interested. I thought some observations of mine a few years ago might interest you, so take the liberty to write to you. About six years ago I was crossing Grant Street bridge (which runs across the shallow mud flats south of the city) in July; the tide was making and the water perfectly clear. I saw a large school of pogies, or perch, *Damalicthys argyrosomus;* their actions were so peculiar that I stopped and called the attention of passers-by to them.

The identification of the fish I am sure of, but can state the year and the season only approximately. The perch were swimming around very leisurely, when two would approach, swimming in the same direction, and when about their length apart would turn on their side and come in contact, still moving ahead slowly. They made apparently no effort to remain together, but after an instant would separate and resume their normal position. I did not observe whether the act was repeated by both, but in one instance I was sure that one of them immediately came in contact with another in the same manner.

I recognized the act as one of copulation, as also did the other observers. Any further information, if it is, that I can furnish I will gladly do so, though I am not posted on the fishes, but have always been an observer of natural objects coming before me.

I remain yours,

P. B. RANDOLPH.

PUBLICATIONS RECEIVED.

Books.

GAUPP, OTTO. — Herbert Spencer. (Frommanns Klassiker der Philosophie, V.) Stuttgart, Frommann, 1897. 1.75 marks.

JAYNE, HORACE. — Mammalian Anatomy; A Preparation for Human and Comparative Anatomy. Pt. I, The Skeleton of a Cat compared with the Skeleton of Man. Philadelphia, Lippincott Co., 1898. $5.00.

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THE ORIGIN OF THE MAMMALIA.[1]

HENRY FAIRFIELD OSBORN.

THE most important problems in vertebrate morphology at the present time are the connections which once existed between the great vertebrate classes. As regards the three lower classes, the present state of opinion is as follows: The Amphibia are derived by Pollard, Cope, Dollo, and Baur from the ancient crossopterygian fishes, an order represented by the modern Polypterus and Calamoicthys, the Dipnoi being regarded as a parallel rather than an ancestral line. The Reptilia, as represented by their most primitive order with solid-roofed skulls (Cotylosauria, Cope, or Pareiasauria, Seeley), are believed to have sprung from that type of stegocephalian Amphibia which possessed rachitomous vertebræ, or with centra and intercentra. This division between reptiles and amphibians must have occurred as far back as the base of the Permian, or even in the Upper Carboniferous, because in the Middle Permian we find several orders of highly specialized reptiles, namely, the Cotylosauria, Cope, Proganosauria, Baur, Dicynodontia, Owen, and Theriodontia, Owen, highly specialized in the so-called Gom-

[1] A paper presented in part before the British Association for the Advancement of Science at Toronto, and in full before the New York Academy of Sciences. Jan. 10, 1898.

phodontia and Cynodontia. Allied to the Proganosauria, moreover, are such widely diverse types as Palæohatteria, Protorosaurus, and Kadaliosaurus.

The origin of the Mammalia is enshrouded in still more doubt. Without the aid of paleontology, Huxley, in 1880, related his Hypotheria, or oldest types of mammals, to the ancient Amphibia.

In the writer's full notes upon Professor Huxley's lectures delivered in his course of 1879–80 occurs the following sentence: "When we find a form that bridges over this gap (that is, between lower vertebrates and mammals) it will in all probability have *a double condyle caused by a reduction of the basioccipital and increase of the exoccipital parts.* The quadrate will have begun to diminish and the squamosal to enlarge, coming into relation with the angular and surangular. That this promammal will be discovered when the immense number of reptilian remains from the older rocks are studied I myself have little doubt." This the writer regards as a more successful forecast than that published by Huxley a year later. At this time he was evidently thinking over his now famous paper of Dec. 14, 1880,[1] in which occurs the following paragraph: "Our existing classification has no place for this submammalian stage of evolution (already indicated by Haeckel under the name of *Promammale*). It would be separated from the Sauropsida by its two condyles, and by the retention of the left as the principal aortic arch; while it would probably be no less differentiate from the Amphibia by the presence of the amnion and the absence of branchiæ in any period of life. I propose to term the representatives of this stage Hypotheria; and I do not doubt that when we have a fuller knowledge of the terrestrial vertebrata of the later Palæozoic epochs, forms belonging to this stage will be found among them. . . . Thus I regard the amphibian type as a representative of the next lower stage of vertebrate evolution. From the Hypotheria, as schematically shown on page 659, in which the mandible articulates with the quadrate, were derived the Prototheria, in which the large free malleus takes the place of the quadrate; from this type sprang the Metatheria, and from these, in turn, the Eutheria."

It is clearly implied by Huxley that the promammal had the paired occipital condyle of the ancient Amphibia, — an assumption of great morphological importance, and differing from that expressed in his earlier lecture quoted above. He also, in his preconception of the homology of the quadrate with the malleus, lightly passes over the difficulty of freeing the quadrate from the squamosal, to which it is closely joined in all the Amphibia. In brief, this brilliant paper lacks the author's usual unsparing logic.

[1] On the Application of the Laws of Evolution to the Arrangement of the Vertebrata, and More Particularly of the Mammalia. *Proc. Zool. Soc. of London*, Dec. 4, 1880, p. 659.

This amphibian hypothesis has recently been supported by Hubrecht (1896), who upon embryological grounds specifically connects the mammals with the stegocephalian Amphibia.

He concludes his very interesting and suggestive lecture, "The Descent of the Primates," by the passage (p. 31): "In fact, there is really not one potent reason which would prevent us from deriving arrangements, as we find them in the placental mammals, directly from viviparous amphibian ancestors." Again (p. 37): "My own choice is fixed upon the latter hypothesis, because in the Amphibia, from which I suppose the earliest placental mammals to have been derived, we find arrangements that appear to explain the origin of the amnion in the way here advocated."

There are numerous structures in the soft anatomy, not only of the monotremes, but of the placentals, which recall the amphibian type. Beddard has demonstrated the existence of an anterior abdominal vein in the monotremes. Howes [1] has compared the amphibian epiglottis with that of the mammals. Hubrecht [2] directs our attention to Klaatsch's [3] comparison of the close relations existing between the intestinal arteries of mammals and the most primitive arrangements of these vessels among amphibians. Elsewhere Hubrecht (*op. cit.*) declares that the mammals must be connected with very primitive forms that have already diverged from the common stem of the Chordata below the point of divergence of the amphibians now living, or, as we should add, from the stegocephalian type. Maurer [4] concludes that in the epidermal sense organs and hairs the mammals diverge considerably from the Sauropsida.

Cope, on the other hand, in 1884, derived the mammals from carnivorous reptiles of the group Theromorpha and order Pelycosauria.

Professor Cope, upon discovering the foot of the pelycosaurs with its supposed posterior spur, compared it with that of the monotremes, and hastened to the conclusion that these animals stood very near the ancestors of the mammals. He was long on record as deriving the Reptilia from the Batrachia with *embolomerous* (rather than rachitomous) vertebræ, and from the pelycosaurian Reptilia, the Mammalia. In his *Primary Factors of Organic Evolution*, 1896, he writes: "I have traced the origin of the mammal to theromorous reptiles of the Permian." In this latest expression of his opinion upon the subject, however, he divided the Theromora into Theriodontia, Pelycosauria, and Anomodontia, and upon the opposite page

[1] G. Howes, *Proc. Zool. Soc. of London*, 1887, p. 50.

[2] *Op. cit.*, p. 38.

[3] H. Klaatsch, Zur Morphologie der Mesenterialbildungen am Darmcanal der Wirbelthiere. *Morph. Jahrb.*, Bd. xviii, Sec. 643.

[4] F. Maurer, *Morph. Jahrb.*, Bd. xviii.

gave a phylogeny of the Mammalia, which showed that his latest views coincided with those here expressed, and that he recognized the force of Baur's criticisms cited below.

Baur in 1886 dissented from Cope's specific conclusion, but committed himself to the theory of indirect reptilian origin of the mammals, by substituting the term Sauro-mammalia for Huxley's Hypotheria, and placing the Theromorpha as parallel, rather than ancestral, to the Mammalia.

Professor Baur's paper of 1886, "Ueber die Kanäle im Humerus der Amnioten," demonstrated that the known Theromorpha are much too specialized to be regarded as ancestors of the mammals, as Professor Cope supposed. To the hypothetical group which gave origin to both Theromorpha and Mammalia Baur gave the name Sauro-mammalia, expressing a similar view in his essay of 1887, "Ueber die Abstammung der Amnioten Wirbelthiere," *Gesell. f. Morph. u. Physiologie*, München, 1887. In his recent paper (1897), showing that the pelycosaurs are highly specialized reptiles, Baur, however, gave his strong adherence to the theriodont ancestry as follows: "We are fully convinced that among these South African forms, one of which (Tritylodon) was for a long time considered a mammal, we have those reptiles which might be considered as ancestral to the mammals, or at least closely related to their ancestors. Further finds and careful critical observations have to decide this."[1]

The writer, in his university lectures of 1896, advocated the same view, having been strongly impressed during the previous year with Professor Seeley's descriptions of Cynognathus and the Gomphodontia.

Osborn,[2] in 1888, selected the Upper Triassic mammals Dromatherium and Microconodon as types of the mammalian order Protodonta, with teeth transitional between those of reptiles and mammals. Subsequently, in 1893,[3] he accepted Baur's view, deriving both the Promammalia and Theromorpha from Permian Sauro-mammalia.

In fact, Cope long diverted our attention from these South African theromorphs, which as originally perceived by Owen in 1876 are full of mammalian analogies, to the pelycosaurs

[1] On the Morphology of the Skull of the Pelycosauria, and the Origin of the Mammals. By G. Baur and E. C. Case. Zoological Club, University of Chicago, February 10; also *Science*, April 9, 1897, pp. 592–594.

[2] On the Structure and Classification of the Mesozoic Mammalia. *Journ. Acad. Nat. Sci.*, p. 251, Philadelphia, 1888.

[3] Rise of the Mammalia in North America. *Proc. Am. Assoc. Adv. Sci.*, p. 188, 1893.

which prove to be unrelated to the theromorphs and still less to the mammals.

The most important series of explorations in the Karoo Beds of South Africa, directed by Professor Seeley, thus turn our thoughts upon the origin of the mammals into the old channel considered by Owen, in spite of his indefinite views of evolution. The animals first described by him as Cynodontia and later as Theriodontia in 1876, both terms being given in full recognition of the resemblances which these animals presented to the Mammalia in their teeth, are, thanks to these explorations, very much more fully known. Seeley's successive memoirs

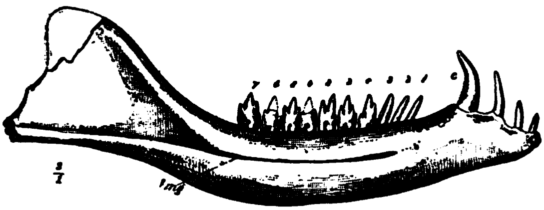


FIG. 1. — Jaw of *Dromatherium sylvestre*, a protodont from the Upper Triassic of North Carolina.

detail many of their numerous points of likeness to the recent and extinct Mammalia. These memoirs may therefore be reviewed in connection with previous speculations as to the ancestry of the mammals. We may critically consider the question of resemblances, in order to determine how far we are justified in supporting the hypothesis that the mammals sprang from the theriodont reptiles.

Seeley (1896, pp. 183, 184) has recently referred the species *Labyrinthodon rütimeyeri* of Wiedersheim to a new genus, Aristodesmus. After pointing out the numerous resemblances of this form to the monotremes, he closes as follows :

> In conclusion, the author argues that the points of structure are so few in which monotreme mammals make a closer approximation to the higher mammals than is seen in this fossil and other Anomodontia that the monotreme resemblances to fossil reptiles become increased in importance. He believes that a group Theropsida might be made to include Monotremata and Anomodontia, the principal differences (other than those of the skull) being that monotremes preserve the marsupial bones, the atlas vertebra, and certain cranial sutures. Ornithorhynchus shows prefrontal and postfrontal bones, and has the malar arch formed as in anomodonts.

Aristodesmus, which suggests this link, is at present placed in the Procolophonia, a group separated from its recent association with Pareiasaurus, and restored to its original independence because it has two occipital condyles, with the occipital plate vertical and without lateral vacuities, and has the shoulder girdle distinct from Pareiasauria in the separate precoracoid extending in advance of the scapula.

A similar view is that of Mivart, who removes the monotremes so far from the marsupials and placentals as to conclude that they arose from sauropsidan ancestors, while the higher mammals, marsupials and placentals sprang independently from Amphibia-like stem forms.[1]

I. CHARACTERS OF THE PROMAMMAL.

It is obvious that to establish a point of connection we should first take characters furnished by the most ancient members of the class of mammals and picture the mammalian prototype or promammal.

As regards the teeth, I made such an attempt in 1893 (*Rise of the Mammalia*) in the following terms:

> The Permian Sauro-mammalia (Baur) with a multiple succession of simple conical teeth divided into: (1) Theromorpha, which lost the succession and in some lines acquired a heterodont dentition and triconid single-fanged molars; (2) Promammalia. The hypothetical Lower Triassic Promammalia retained a double succession of the teeth; they became heterodont, with incipient triconid double-fanged molars, the dental formula approximating 4, 1, 4–5, 8. They gave rise to three groups: (*a*) The Prototheria, which passed rapidly through the tritubercular into the multitubercular molars in the line of multituberculates, and more slowly into trituberculy, and its later stages in the line of monotremes. (*b*) They gave off the Metatheria, or marsupials, and finally (*c*) the Eutheria, or placentals.

In the same address I took very positively the position that the simple reptilian cone is the ancestor of the multitubercular as well as of the tritubercular dental types, and that the multituberculate teeth observed in the Triassic were not primitive, but had precociously passed through a tritubercular stage. I derived the characters of the promammal from a study of all the known Jurassic Mammalia. The inference as to the multiple succession of the teeth I subsequently based upon the recent embryological demonstration that all living mammals are diphyodont and sprang from polyphyodont ancestors (a principle that

[1] *Proc. Roy. Soc.*, vol. xliii, p. 372.

has recently been thrown in doubt by Woodward). The hypothesis as to the derivation of the multitubercular from the tritubercular teeth was based upon the fact that certain rodents, although unquestionably of trituberculate origin, present typical multituberculate teeth. Summing up as follows: The *Lower Triassic ancestors of monotremes, marsupials, and placentals possessed teeth differentiating into different kinds* (*incipiently heterodont*), *molars with three cones* (*triconodont*) *and dividing fangs* (*Proto-*

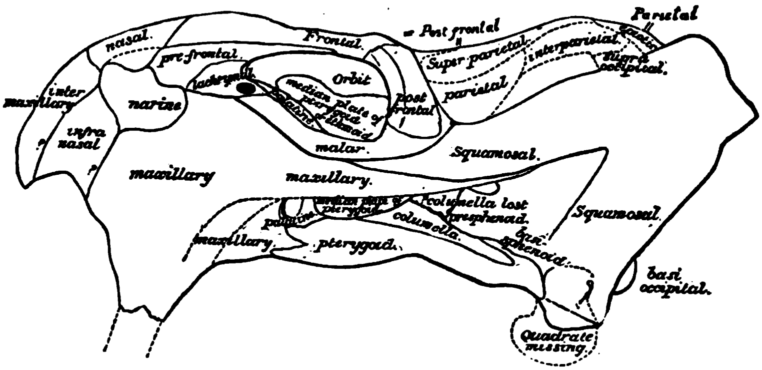


FIG. 2. — Lateral view of the skull of Dicynodon, showing Seeley's interpretation of the cranial elements. (After Seeley.)

donta), *giving rise both to the multituberculate and trituberculate types, with the dental formula: incisors, 4; canines, 1; premolars, 4 or 5; molars, 8.*

These assumptions are in a measure confirmed by Professor Seeley's discoveries, but the Theromora in the large sense reassume a position *ancestral* to rather than *parallel* with the mammals. Before bringing out all the grounds for this statement let us review the osteological and dental promammal characters side by side with theriodont characters.

II. History of Discovery.

Professor Owen defined the Theriodontia in 1876 as follows: "Dentition of a carnivorous type; incisors defined by position, and divided from molars by a large laniariform canine on each side of both upper and lower jaws, the lower canine crossing in front of the upper; no

ectopterygoids; humerus with an entepicondylar foramen; digital formula of fore foot, 2, 3, 3, 3, 3 phalanges."

No definition could be clearer, and upon the following page Owen suggests the hypothesis that these forms may have given rise to the mammals "by secondary law, the mode of operation of which we have still to learn."[1]

This definition was subsequently enlarged by Owen himself, and has been extended by Seeley. So that now this order includes forms having great diversity in their dentition, but apparently related in their osteological characters.

FIG. 3. — Palatal and superior views of the skull of Dicynodon, showing the elements as interpreted by Professor Seeley. Note especially the exposure of the vomer, the large extension of the squamosal, the pre- and postfrontals, the single squamoso-maxillary bar.

Thus, says Seeley (1895, I, p. 997), the Theriodontia as originally defined included: first, the group of animals with skulls formed on the type of Lycosaurus[2] with simple pointed teeth; second, the group with skulls formed on

[1] *Quar. Journ. Geol. Soc.*, pp. 95–101, May, 1876.

[2] With this group of theriodonts Case, in a recent paper (*American Naturalist*, February, 1898, p. 73), also associates the Lycosauria; Lycosaurus being a type which furnishes a transition from the supposed fusion of the upper and lower temporal arches into the single zygomatic arch of the Mammalia, as shown in the following synopsis:

Cynodontia: Quadrate covered by supporting bones. Teeth showing small lateral tubercles. Arches more closely approximated than in Procolophonia.

Lycosauria: Quadrate small, covered by supporting bones. Skull depressed. Teeth with well-developed tubercles. Arches united.

Gomphodontia: Quadrate very small and inclosed in squamosal. Teeth tuberculate. Palate mammalian. Arches united.

the type of Thrinaxodon, which lacked the incisor teeth. One of the principal features in common is the structure of the palate, resembling that of the Mammalia in the opening of the palato-nares between the molars.

Seeley distinguishes the theriodonts from the dicynodonts by the following characters: The postorbital arch is similar, but in the theriodonts the malar bone has a greater backward extension, and in the dicynodonts the squamosal has a greater downward development, the latter difference being due to *the degeneration of the quadrate in the theriodonts*. Dicynodon, moreover, has a tripartite condyle, as in the Chelonia (composed equally of basi- and exoccipitals); while the theriodonts have paired condyles, as in the Mammalia (1895, 5, p. 129), with a depressed basioccipital portion. Both types show mammalian analogies in the palate, as well as a fixed and reduced quadrate.

FIG. 4.—Posterior view of the occiput of *Ptychosiagum declive*. A dicynodont, showing the tripartite structure of the occipital condyle, the large interparietal, the extension of the squamosal upon the occiput. The bones lettered *ps* correspond in position with the epiotics in the labyrinthodont amphibia. (After Lydekker.)

In the palate of Dicynodon the palatine bones are separated by the vomers in the median line. The occiput is broad and flat, bounded by the parietals and interparietals above, there being a deep notch in the median line. The bones doubtfully described by Owen as paroccipitals ("opisthotics" of Huxley) are fused with the exoccipitals, as observed by Huxley in Ptychognathus and by Seeley in other forms. Laterally, the occiput is formed by the *squamosals*, elements which are very extensively developed in Dicynodon, largely covering the quadrate and descending to form *nearly half of the glenoid facet for the lower jaw*, a very important character. In this respect this genus is more mammalian than the theriodonts, in which the squamosal does not form part of the glenoid facet.

In the palate, however, the theriodonts are more mammalian, since the palatine bones meet in the median line defining the posterior nares. In both types the orbits are closed posteriorly by the postorbitals and postfrontals. The zygomatic arch in both has a large malar as well as a large squamosal.

The shoulder girdle in both presents a metacoracoid and epicoracoid, the latter perforated by a foramen, as well as a clavicle and interclavicle, thus strongly resembling the monotreme type. Dicynodon, like Gomphognathus among the theriodonts, has a decidedly promammalian type of humerus, with a prominent deltopectoral crest, an entepicondylar foramen, and prominent ent- and ectepicondyles. The pectoral arch exhibits a narrow scapula and large epi- and metacoracoids entering also into the glenoid fossa. The pelvis shows an ilium expanded above, a ventrally united ischium, and pubis with a rudimentary obturator foramen, all three bones entering equally into the acetabulum.

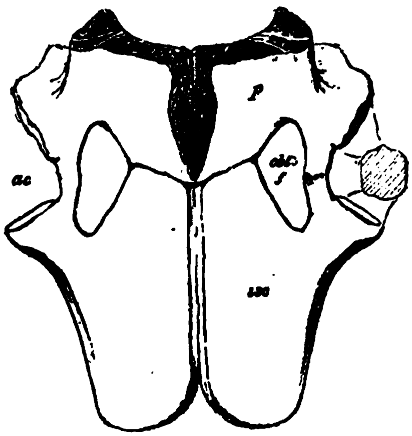


FIG. 5.— Ventral aspect of the pelvis of Cynognathus, showing the relations of the pubis, the ischium, obturator foramen. (About ⅓ natural size. After Seeley.)

It is clear that the dicynodonts and theriodonts hail from a common stock, the superorder Thermora of Cope, the former showing the greater specialization and aberrancy. To this superorder the term Anomodontia is given by most English authors, but it is inapplicable, because Owen invariably defined the Anomodontia in such a manner as to embrace only the dicynodonts. The first comprehensive term was that given by Cope.

III. ORDER THERIODONTIA, OWEN.

It is a most striking fact that the theriodonts proper appear to include two suborders, which, so far as we know, are as

closely united in skeletal characters as they are dissimilar in dental characters. These are:

1. Suborder *Cynodontia:* Carnivorous animals, with cutting triconodont molars.

2. Suborder *Gomphodontia:* Herbivorous animals, with triturating, low-crowned, tritubercular and multitubercular teeth.

The teeth of these animals are even more widely differentiated than those of the Mesonychidæ and Arctocyonidæ among the Creodonta. Compared with living types, they are as wide apart as those of Thylacinus and Mus. Upon the "tritubercular theory" the dentition of the cynodonts is the most primitive. Upon the "multitubercular theory" it would be considered the most specialized.

The skeleton of the Cynodontia is by far the best known.

1. *The Cynodontia.*

The most perfectly known type is Cynognathus. The skull of Cynognathus is over a foot (15¾ inches) long. This animal was a large and powerful carnivore, the tooth structure

Pro.

FIG. 6.— Lateral view of skull of *Cynognathus crateronotus*, showing the dentary element in the mandible, the incipient angle; the compound nature of the zygomatic arch, with an open infratemporal fossa, *in*. (⅓ natural size. After Seeley.)

superficially resembling that of Thylacinus or Dissacus. The skull widens posteriorly, but in lateral view it is strikingly mammalian and cynoid (1895, 5, p. 61). The anterior nares are divided, terminal and lateral, the snout as seen from above

being bulbous, as in Tritylodon, covered by long nasals with a short free portion. Large lachrymals, and, conforming with the carnivorous habit and strong temporal muscles, there is a high sagittal crest, deep temporal fossæ and a strong, deep zygomatic arch, powerful chin and coronoid process (formed from the dentary). The serrated teeth agree in number with Osborn's promammalian formula, consisting of four incisors, powerful canines, five pointed and basal cusped premolars, and four triconid molars. As in the Protodonta, the molar fangs are slightly grooved, indicating a division into two roots.

There are also incipient traces of a cingulum (1895, 5, Fig. 2) and some evidence that there was a succession of the teeth

Fig. 7. — Lateral view of the teeth of *Cynognathus crateronotus*, showing the five simple premolars and triconodont molars with grooved fangs. (½ natural size. After Seeley.)

(1895, 5, p. 62). All these are promammalian characters. A close approximation to this type is in the marsupial Triconodon of the Upper Jurassic. Professor Seeley has pointed out (1895, 5, p. 90), also, that there exists a still closer resemblance between this type and Microconodon.

A perforation behind the orbits, which Cope and Baur, and very recently Case,[1] have considered as possibly representing the infratemporal fossa, is regarded by Seeley as a vacuity. Upon page 74 (1895, 5) Seeley also compares this vacuity with the infratemporal fossa. According to this interpretation, the mammalian zygoma was originally a compound structure, composed of the squamosal + prosquamosal above and the quadratojugal below. A palate, formed apparently by hori-

[1] *American Naturalist*, February, 1898, p. 73. This paper contains a valuable critique of the same subject from the standpoint of the temporal arches.

zontal palatine and maxillary plates, and two (exoccipital) condyles complete the mammalian facies.

The origin of the paired occipital condyles of the Mammalia is a matter of great importance. We observe a tripartite condyle in Dicynodon and in the Chelonia, into which the basi- and exoccipitals enter about equally; certain types of Lacertilia, such as Uroplates and Gecko (*fide* Cope), also evidently acquired their bipartite condyles secondarily by the recession of the median basioccipital element. It would appear, therefore, that the theriodonts, in which this median basioccipital element is still quite prominent, also acquired the paired exoccipital condyle in the same manner, *i.e.*, secondarily, or from the tripartite type, such as that seen in Dicynodon. We would thus have the explanation of the development of this paired structure from a reptilian tripartite condyle, as in Huxley's original conjecture, rather than directly from an amphibian paired condyle, for in the Amphibia the paired condition of the condyles arises in an extremely early period, rather than by a secondary recession of the basioccipital element.

FIG. 8.—External and anterior views of the left shoulder girdle, supposed to belong to Cynognathus, showing the scapula, parts of coracoid, precoracoid, and precoracoid foramen. (½ natural size. After Seeley.)

Of the transitional characters of Cynognathus, the reduced and overlapped quadrate is what we should expect to find in a promammal upon the Albrecht-Cope-Baur theory that the quadrate in the mammalia is fused with the squamosal. Among the reptilian characters are the separate prefrontal and postfrontal elements (the postorbitals being united with the malars), as well as the constitution of the lower jaw out of distinct elements (angular, articular, dentary, splenial), which by reduction and

fusion with adjacent elements might, however, pass into a mammalian prototype.

Some of the peculiar adaptive features of this type are the very elevated position of the squamosals (as in certain plesiosaurs); the paroccipitals or opisthotics exhibit large posterior vacuities, as in Dicynodon, and are united with exoccipitals; basioccipitals narrow; the epiotics are said to be separate (1895, 5, p. 77); the alisphenoids and orbitosphenoids are defined; laterally we observe descending plates of the pterygoids or "transverse-palatine" bones.

The angular region of the jaw of Cynognathus is unfortunately wanting, but it is improbable that the placental type of angle was present. Seeley points out (1895, 5, p. 90) that the rudimentary mammalian angle may consist of the posterior border of the dentary, and concurs with Osborn [1] *that the angle arose anteriorly on the lower border of the jaw* (as perhaps in Microconodon, Amphitherium, and Peramus) *and was subsequently shifted backwards.*

Remains of the shoulder girdle show that a coracoid (metacoracoid) and epicoracoid with foramen were present (as in Dicynodon), and more striking still as a point of resemblance to the monotremes is the spine and acromion of the scapula, consisting of "the anterior edge of the scapula developed upward" (1895, 5, p. 92).

Of the vertebræ preserved (1895, p. 97) there are six cervicals, eighteen dorsals, five lumbars; the first of these has the spine and odontoid process characteristic of the mammalian axis, the atlas being probably lost. The formula is estimated as: C.–6, D.–18, L.–5, S.–4. The writer has estimated the dorsolumbar formula of the primitive mammal at D. = 15, L. = 5, or D.L. = 20. The cervicals exhibit large intercentra (structures seen in a vestigial form in embryonic Insectivora and other mammals), to which, as well as to the centra, the heads of ribs are partly attached, certainly in the case of two vertebræ (*op. cit.*, p. 99), while the rib tubercles unite with the pleurapophyses of the vertebra posterior in true mammalian fashion. In the *dorsal* region (*op. cit.*, p. 104) no intercentra are described;

[1] See *Mesozoic Mammalia*, p. 223.

the heads of the ribs are intercentral or articulate between the centra and the tubercles to the succeeding vertebræ (as in mammals). Certain structures in the dorsal (D.–12) vertebræ resemble a zygophen-zygantrum articulation, compensating perhaps for the imperfectly developed zygapophyses. In the poste-

Fig. 9. — Palate of *Cynognathus platyceps*, showing the composite structure of the lower jaw, the descending transverse plates of the palatines, occipital condyle with a large basioccipital element. ([illegible] natural size. After Seeley.)

rior dorsals the ribs are suturally anchylosed to the vertebræ and extend outwards into overlapping plates. Only two of the supposed sacrals are anchylosed.

The pelvis is remarkably mammalian in the structure of its ventrally united ischium and pubis, with obturator foramen (rudimentary in Dicynodon), the three bones forming the acetabulum. But it differs from the early mammalian type in the widely

expanded supra-iliac border. There is some evidence of the existence of marsupial bones, as in the monotremes and marsupials (*op. cit.*, p. 117). The femur, so far as preserved, is less mammalian in type; the trochanter minor is very prominent and extends far down the shaft.

All the above characters are observed in the single skeleton of *C. crateronotus*. In skulls of *C. berryi* are found two condyles formed from exoccipitals only (*op. cit.*, p. 129), separate pre- and postfrontals, greater coalescence of the jaw elements, an inferior dental formula estimated at:

I, 3.–C, 1.–P, 4.–M, 5.

Another species, *C. platyceps*, an animal about the size of a wolf, lacks the supposed infratemporal opening (Fig. 10) above the malar arch. The quadrate is hardly distinguishable from the squamosal. The lower jaw exhibits evidence of a splenial (*op. cit.*, p. 140) in process of degeneration. A third species,

Fig. 10. — Lateral view of skull of *Cynognathus platyceps*, showing the union of the prosquamosal and malar elements, closing in the infratemporal fossa. Angle developed as in Microconodon. (After Seeley.)

probably generically distinct, is *C. leptorhinus*, with a median nasofrontal pit upon top of the face and two specialized canines.

A carpus doubtfully referred to Cynognathus (1895, 5, p. 145) exhibits elements which Seeley interprets as a united scapholunar, cuneiform, pisiform, and portions of the centrale.

2. *The Gomphodontia.*

All the remains of this group have been found in the upper Permian Beds of Ailwell North and Lady Frere, contemporary with the specialized theriodonts. The geological position of Tritylodon is not certainly known, but the other gomphodont genera, Gomphognathus, Microgomphodon, Trirachodon, and Diademodon, are certainly located in these upper Karoo Beds, and are below the Stormberg Beds, which are considered Triassic. Seeley (1895, 4) confidently places these animals in the order Theriodontia (contrasting them with the carnivorous Cynodontia) as typical herbivorous forms with molar teeth flattened and expanded transversely and more or less tuberculate crowns. The cranial and skeletal characters, so far as they are

FIG. 11. — Anterior and posterior views of a right humerus referred to Gomphognathus, showing powerful deltoid crest, entepicondyle, entepicondylar foramen; separate articular facets for radius and ulna. (½ natural size. After Seeley.)

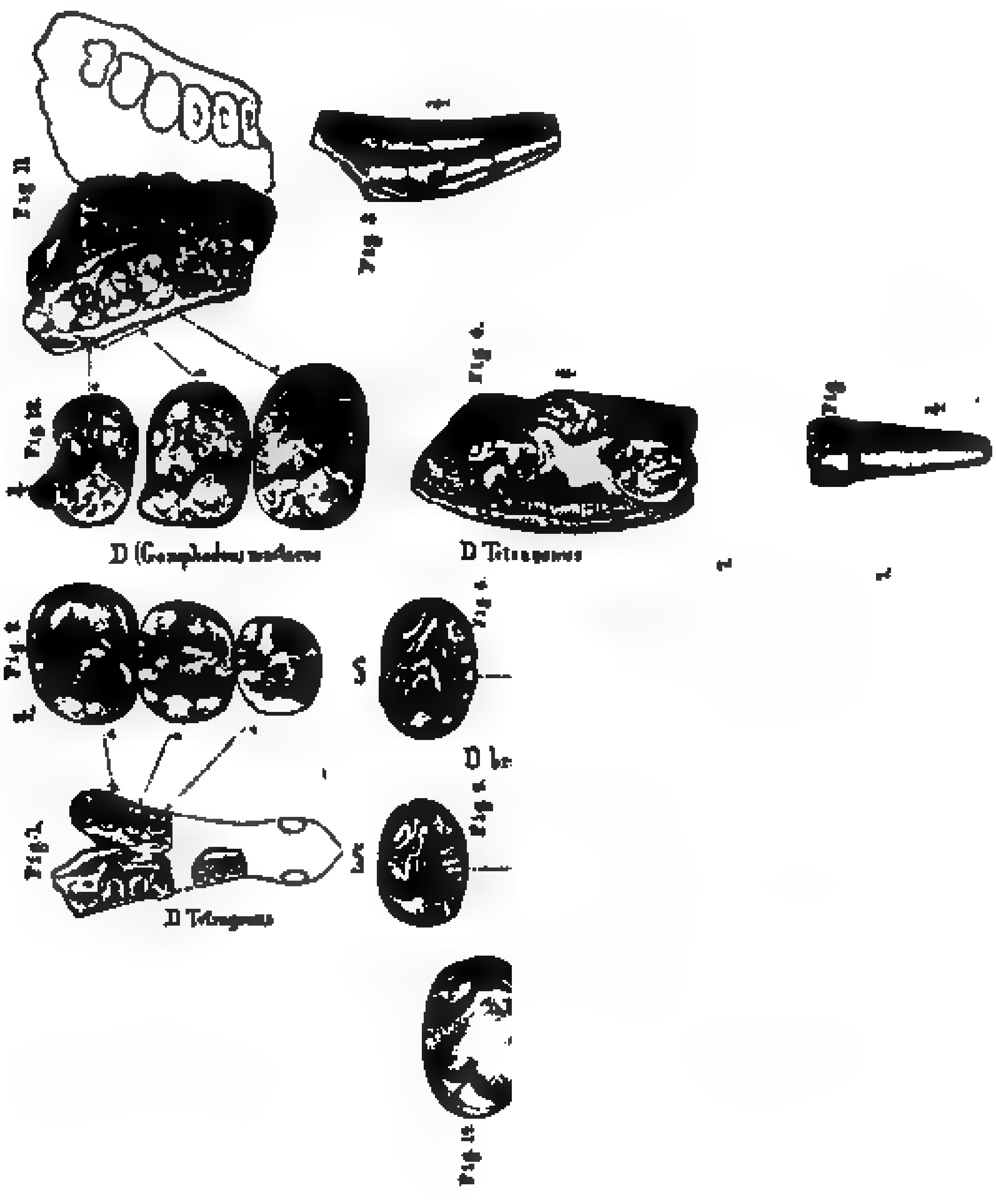
known, support Seeley's conclusion, and the wide diversity in the structure of the teeth does not alone constitute a sufficient ground for the separation of these herbivorous forms from the carnivorous Theriodontia. If Tritylodon belongs to this group,

as seems to be very probable if not absolutely demonstrated, it is certainly the most highly specialized, in the possession of strongly developed intermediate tubercles on the upper molars, which are only feebly developed in Diademodon.

The skull is partly known in the genera Gomphognathus, Microgomphodon, and Trirachodon. As in the Cynodontia, the temporal fossæ are separated by a more or less distinct sagittal crest, less prominent than in the Cynodontia because of the reduction of the temporal muscles. As in the Cynodontia, the zygomatic arch is formed by the malar and squamosal bones, and the orbit is separated from the temporal fossa by the post-orbital (postfrontal, Seeley) bone. There are two well-defined occipital condyles at the back of the base of the skull, united to each other inferiorly in a way that is closely paralleled in some mammals. The occiput is triangular and more or less concave. It lacks the large lateral foramen which distinguishes the occiput in the carnivorous Cynodontia. Externally at the sides of the occiput there is a deep notch where the squamosal bone is given off to the zygoma. The malar bone extends behind the orbit as in the mammals, and unites with the squamosal to form the larger part of the zygoma, developing a small descending process. The hard palate formed of the maxillary and palatine bones terminates in the middle of the molar region. Behind this, sharply distinguishing the palatal region from that of the mammals, there is a transverse descending arch apparently composed of the transverse bones, extending downwards so that it abuts against the rami of the mandibles, as in the Crocodilia, Rhyncocephalia, and Lacertilia. The most important resemblance to the Cynodontia is the degenerate condition of the quadrate bone, which, in the words of Seeley, "appears to be reduced to a small ossicle imbedded in the squamosal bone, but exposed in its posterior aspect behind the articular condyle of the lower jaw, into which it appears to enter."

The dentition is highly specialized. The incisor teeth are small and pointed. The canines are reduced in Microgomphodon, practically resembling the incisors. In other forms they are large, compressed, with serrated margins, as in the cyno-

donts. The homologies of this tooth in Tritylodon are uncertain. The premolar teeth are small and circular, usually tuberculate, but occasionally the first tooth is compressed laterally. The



Tritylodon

FIG. 12. — Dental and cranial structures of the Gomphodontia. *D. masticus*, analogous to a low-crowned trituberculate, like Arctocyon *D. tetragonus*, trituberculate structure more obscure. *D brachylicra*, resembling the lower molars of Microlestes from the Rhætic of Germany, showing the incipient division of the fang. The skull of Tritylodon is greatly reduced. (After Seeley.)

molar teeth are usually single rooted, arranged in close-set series, which diverge sharply outwards as they extend backwards; with grinding surfaces varying in form and character, but with internal and external cusps more prominent than the

other tubercles of the crown. It is important to direct attention to this divergence of the dental series posteriorly, which shows that these animals are not typical multituberculates like Tritylodon, in which animal the dental series are parallel with each other as an adaptation to the forward and backward motion of the jaws. The lower jaws are formed, as in the theriodonts, by rami which are coalesced at the symphyses, consisting externally of dentary bones which are produced posteriorly into a high coronoid process, and exhibit also an inferior posterior angle, a character which is entirely wanting in the Eocene Multituberculata. As in the cynodonts and typical reptiles, the jaws unite with the skull by elongate articular bones.

So far as known (1895), there are no fundamental differences in the skeleton to separate the Gomphodontia from the Cynodontia, and these two groups are regarded by Seeley as related in the same way as are groups of marsupials with similarly differing dentition. The skeleton doubtfully referred to Microgomphodon shows a distal transverse expansion of the ribs into triangular extremities, as in Cynognathus, so as to form an interlocking union similar to that of the zygapophyses on the neural arch. In the same skeleton the pelvis resembles that of the Cynodontia, except in the apparent exclusion of the pubic bone from the acetabulum. For in the Cynodontia the pubis takes its normal part in forming the acetabulum. The long, lateral trochanter of the femur is less developed than in the Cynodontia. In the tarsus the astragalus and calcaneum are both large bones, but the calcaneum exhibits no tuber calcis. The scapula is constructed on the same plan as in Cynognathus. The same is true of the humerus. The interclavicle is thin, wide, and long.

Tritylodon.

The skull of *Tritylodon longævus*, described by Owen in 1884, was placed hesitatingly with the Jurassic and Eocene Multituberculata until reëxamined by Seeley in 1892 (1895, 2, p. 1025). He refers the skull to the Lady Frere level, and finds some evidence that the orbit was closed posteriorly, as among the theriodonts, Professor Owen having assumed that

the orbit was open behind. He further observes the narrowing of the skull in front of the orbits and the bulbous aspect of the snout as a more definite character relating Tritylodon to the other theriodonts. As regards the enlarged front teeth, which have hitherto been considered as incisors, he thinks it is possible, since their roots ascend into the maxillary, that they may be canines. The skull further agrees with that of the theriodonts in the terminal position of the anterior nares and in the median anterior process of the premaxillary, which forms an internarial septum, also in the position of the posterior nares opening between the hinder molar teeth. The most characteristic region of the theriodont skull is that bordering the orbit, in which, unfortunately, the type specimen of Tritylodon is imperfectly preserved, so that it is impossible to determine positively whether there was a postorbital bar composed of the postorbitals (postfrontals, Seeley) as in the Theriodontia; the fossil shows an oblique fracture at this point, and the converging plates, described by Owen as the parietal bones, are regarded by Seeley as the posterior processes of the postfrontal bones, because they are closely comparable to the similarly placed bones of the theriodonts. The prefrontal bone, on the other hand, appears distinctly as forming the antero-superior border of the orbit. "Hence," Professor Seeley concludes, "I believe that the remains of the skull go to show that Tritylodon was a reptile, and that the skull might be restored upon the theriodont plan." In the same paper Professor Seeley figures (1895, 2, p. 1028) a portion of the lower jaw.

Diademodon.

This genus was founded by Seeley on the characters of the molar teeth (1895, 3, p. 1030, Pl. LXXXIX, Fig. 11). He describes the superior molars as wider than the inferior, with the crown low, subquadrate, or transversely oval. As pointed out by the writer in *Science*, these upper teeth are of extraordinary interest, since they show *the typical tritubercular pattern.* While the crown is roughly tubercular, the four prominent cusps correspond with the protocone, paracone, metacone, and hypo-

cone, respectively, the last being much the smallest, and there are two irregular intermediate cusps which represent the conules.

These characters are fairly well seen in the species *D. tetragonus*, discovered in 1884, the type being a small skull about three inches in length. In Seeley's language (1895, 3) the general effect of this cuspidate structure is that there is a sharp cuspidate girdle surrounding the subquadrate or subovate crown, with one cusp strongly developed on the outer margin, and two strongly developed on the inner margin. He found no remains of incisor teeth in this specimen, although they may have been present. Probably associated with this type were two small canines; the reference of these teeth, however, is doubtful. There may have been three small teeth in the position of premolars and seven in the position of molars, although the fragments only indicate five.

There were two isolated molar teeth found at the same time (represented in *loc. cit.*, Pl. LXXXIX, Figs. 6–9), of very small size, which Professor Seeley doubtfully proposed as the type of the distinct species *D. brachytiara*. These teeth are extraordinarily similar to those of Microlestes of the Rhætic of Germany, hitherto regarded as a typical multituberculate related to the Plagiaulacidæ.

It is the species *D. mastacus*, however (*loc. cit.*, Pl. LXXXIX, Figs. 11, 12), which presents the significant resemblance to the tritubercular pattern in its molar teeth above mentioned. In fact, while not specifically mentioning these strong tritubercular resemblances, Seeley observes (1895, 3, p. 1037): "There is nothing with which these teeth can be compared, except the molars of some of the higher groups of mammals." The teeth, however, have but one root and belong to skulls which are undoubtedly theriodont.

In the species *D. Browni* the crown is of a still simpler tubercular pattern, with one large internal and evidences of two external cusps.

General Conclusions.

It is obvious that we must await a more complete knowledge of the skeleton of these various forms before we can confidently either classify them or establish their relations to Mammalia. The literature is in considerable confusion, and requires a more careful and exhaustive revision than I have been able to give it. It appears that the mammalian resemblances of these animals include a very large number of characters which are observed without exception in the basal Eocene or Puerco fauna of North America.

The anticipation of the triconodont and multituberculate type of dentition of the Jurassic period is remarkable. If actually phyletic, it points to an extremely early divergence of these dental types — much earlier than the period of the Protodonta.

The general resemblances with existing and basal Eocene types of mammals may be summed up as follows:

Theriodont Characters.	*Promammalian Characters.*
1. Teeth heterodont, four series; molars single rooted or with grooved fangs of triconodont and multitubercular type.	1. Same characters observed in Protodonta, Multituberculata, and Triconodonta, except that the latter have completely paired molar fangs.
2. Anterior nares terminal. Posterior nares placed far back and roofed over by palatines and maxillaries.	2. The same in basal Eocene mammals.
3. Nasals narrow anteriorly, expanding posteriorly.	3. The same in basal Eocene mammals.
4. Separate prefrontals; separate postorbitals closing orbits posteriorly.	4. No prefrontals or postorbitals. Orbits open posteriorly in all basal Eocene mammals.
5. A single infratemporal or *zygomatic* arch consisting of malars and squamosals (or consisting of fusion of upper with lower arches, Baur, Case).	5. An infratemporal or zygomatic arch only.
6. Quadrate reduced and overlapped by squamosal.	6. Quadrate probably coalesced with squamosal, occasionally separated by reversion (Albrecht).

Theriodont Characters.	*Promammalian Characters.*
7. Separate transversum as in Reptilia and a distinct prevomer in certain types.	7. Transversum and prevomer missing.
8. Paired exoccipital condyles with prominent median basioccipital element.	8. Paired condyles on exoccipitals only, with basioccipital element reduced.
9. Lower jaw composite, including dentary, articular, angular, and splenial.	9. Lower jaw composed of a single bone.
10. Cervical vertebræ with intercentra.	10. Cervicals and dorsals with embryonic intercentra in Insectivora.
11. Cervical ribs separate, suturally united with vertebræ.	11. The same in monotremes and embryos of higher mammals.
12. Anterior dorsal ribs intervertebral in position with head intercentral and tubercle neurocentral.	12. The same.
13. Scapular arch with clavicles and interclavicles; epicoracoid united by suture with the metacoracoid; prescapular spines.	13. The same in monotremes; clavicles and interclavicles wanting in higher types. Prescapular spines in monotremes.
14. Pelvic arch with ischio-pubic symphysis and rudimentary obturator foramen; acetabulum closed; pubic bones secondarily developed.	14. Pelvic arch with closed acetabulum, ischio-pubic symphysis, and large obturator foramen.
15. Carpus and tarsus imperfectly known.	15. Carpus with os-centrale; tarsus with os-tibiale.
16. Humerus with powerful deltopectoral crest, and entepi- and ectepicondyles; entepicondylar foramen.	16. The same in all basal Eocene mammals.

Important, also, among the resemblances between the Theriodontia and Mammalia is the general body form, so far as it is known in the former, the proportions of the limbs to the back, and the apparent elevation of the body considerably above the ground. This, taken together with the peculiar specialization of the teeth into carnivorous and herbivorous types, indicates that the Theriodontia filled somewhat the same rôle in the economy of nature as is filled by the Mammalia at the present time. The most striking general difference is the very large size of several of these animals, such as Cynognathus.

We had rather anticipated from our knowledge of the earliest Stonesfield mammals that their reptilian ancestors would be very small. The large size of these Permian theriodonts, however, is not incompatible with the hypothesis that smaller and less specialized members of the group may have constituted a persistent phylum.

mkg.

FIG. 13. — Triconodon, a typical triconodont from the Upper Jurassic, Purbeck Beds of England. (Original from specimens in the British Museum.)

The reëxamination of the jaws of the Upper Triassic Dromotherium and Microconodon fails to reveal any evidence of a composite nature, that is, so far as it is possible to determine; the jaws consist of single bones, but they are so small that this evidence is not conclusive. The position of the Protodonta, therefore, appears to be unaffected by Seeley's discoveries. The Gomphodontia of Seeley are likewise separated from the Multituberculata of Cope by the composite nature of the jaw, but it remains to be seen how far the more recent multituberculates, such as Polymastodon, which certainly have the single jaw of the mammals, may have retained other reptilian characters in the skull.

FIG. 14. — Jaw of *Microconodon tenuirostre*, a protodont from the Upper Triassic of North Carolina. *A*, supposed rudiment of angle.

We reach the general conclusion that the Theriodontia constitute a group which contains practically all the primitive characters of the Mammalia in the skeleton and teeth, and that no other reptiles or amphibians approach so near the hypothetical promammal. The explanation of the presence of amphibian characters in the soft parts of the existing Mammalia appears to be that the promammal sprang from primitive reptiles which preserved a number of still more primitive amphibian or stegocephalian characters.

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THE WINGS OF INSECTS.

J. H. COMSTOCK AND J. G. NEEDHAM.

CHAPTER III (*continued*).

VIII. THE VENATION OF THE WINGS OF DIPTERA.

In the order Diptera, as in the Trichoptera, a great reduction of wing tracheæ has taken place. Owing to this fact we have not found that any light is thrown on the question of the homology of the wing-veins by a study of the tracheation of the wings of dipterous pupæ. We will, therefore, confine our attention in this place to a study of the wings of the adult.

In this order the tendency towards a cephalization of the flight function, which occurs in nearly all of the orders of

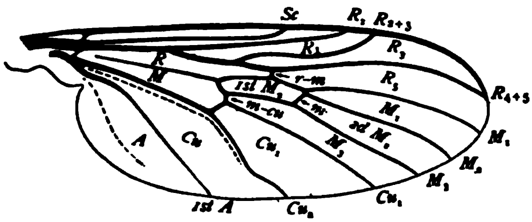

FIG. 29.— Wing of Rhyphus.

winged insects, reaches its maximum development, and has resulted in the complete suppression of the hind wings as organs of flight.

Notwithstanding this great modification of the organs of flight, the remaining pair of wings retain, in the more generalized members of the order, the primitive type of wing venation but slightly modified. So unimportant are the changes that the determination of the homologies of the wing-veins in these forms presents no difficulties.

If a wing of Rhyphus (Fig. 29) be compared with our hypothetical type (Fig. 5)[1], it will be found to correspond very

[1] *American Naturalist*, April, 1898, No. 376, p. 251.

closely with it, the only differences being due to a slight reduction in the number of the veins ; the radial sector is reduced to a two-branched condition, the media is only three-branched, and only one of the anal veins is well preserved.

Although it is an easy matter to determine the homologies of the wing-veins in a generalized form like Rhyphus, it would be exceedingly difficult, if not impossible, to do this in the case of some of the more specialized forms if they alone were studied. But when a carefully selected series of forms is examined the difficulties vanish.

We wish now to call attention to such a series for the double purpose of demonstrating the homologies of the wing-veins in the more specialized forms and of showing the value in taxonomic work of the characters presented by the wings.

It should be borne in mind that the different parts of the wing may be modified more or less independently. Although the wing acts as a whole as an organ of flight, any change in the habit of flight is likely to result in a greater modification of some one part than of others. Thus we may find that in one line of descent a certain part is greatly modified and another part remains but slightly changed from the primitive type ; while in another line of descent the opposite may be the case. It is necessary, therefore, in discussing the changes that have taken place in the venation of the wings to treat the different veins separately. We will, however, refer to only a few of the more important of these changes, as a series of figures illustrating the homologies of the wing-veins of each of the families of this order has already been published by one of us.[1]

The reduction of the radial sector. — In a few genera of flies the radius retains the primitive, five-branched condition ; of these the genus Protoplasa of the Tipulidæ is a good example.[2] But usually the number of the branches of this vein is reduced by a coalescence of some of the branches of the radial sector. Thus in many families the radial sector is three-branched, in others it is only two-branched, and in the gall-

[1] Comstock, *Manual for the Study of Insects*, pp. 413–489.
[2] *Loc. cit.*, Fig. 504.

gnats (Cecidomyiidæ) it is reduced to a simple, unbranched condition.[1]

As this variation in the number of the branches of this vein is due to a greater or less degree of coalescence among them, it is evident that here is a character of considerable taxonomic

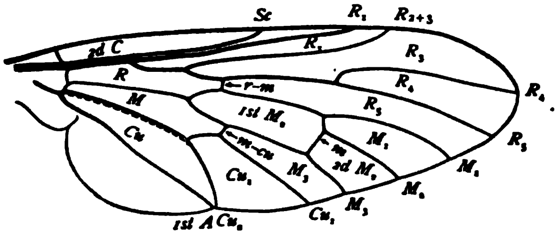

FIG. 30. — Wing of Leptis.

importance, serving as it does to indicate degrees of divergence from the primitive type.

Not only do we find differences in degree of reduction of this vein, but differences in the method of reduction are also shown. If the wing of Leptis (Fig. 30) and of Dixa (Fig. 31) be compared it will be seen that although in each the radial sector is only three-branched, the reduction has been brought about in a different way in the two genera. In Leptis veins

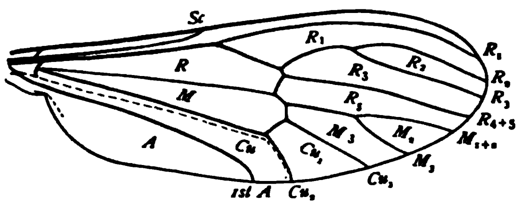

FIG. 31. — Wing of Dixa.

R_2 and R_3 coalesce; while in Dixa it is veins R_4 and R_5 that have grown together. This is a difference in kind of specialization, which indicates that the two forms belong to different lines of descent. The common progenitor of these two genera had a four-branched radial sector; in some of the descendants of this primitive form one method of reduction has taken place, while in other descendants another method has been followed.

[1] *Loc. cit.*, Fig. 522.

That this differentiation took place comparatively early in the history of the order is shown by the fact that in all Nematocera that have a three-branched radial sector veins R_2 and

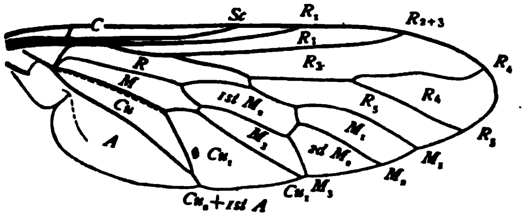

FIG. 32. — Wing of Thereva.

R_3 remain distinct; while in those Brachycera that have a three-branched radial sector veins R_4 and R_5 are separate.

The coalescence of veins M_3 and Cu_1. — One of the most characteristic methods of specialization exhibited by the Dip-

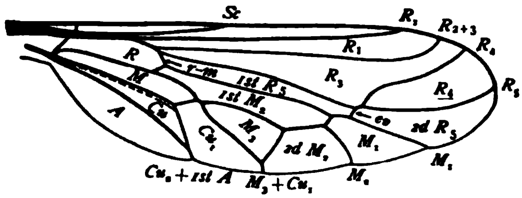

FIG. 33. — Wing of Eulonchus.

tera is the coalescence of veins from the margin of the wing towards the base. This method of coalescence may occur between any two adjacent veins, and sometimes occurs in two or three different regions of the same wing. The most strik-

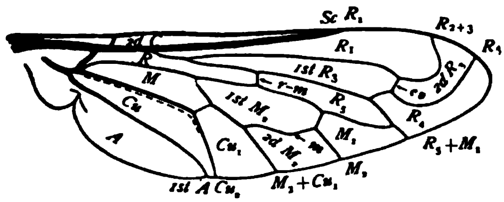

FIG. 34. — Wing of Pantarbes.

ing modifications in the courses of the wing-veins have been brought about in this way. Let us examine a series illustrating different degrees of coalescence of veins M_3 and Cu_1.

In Rhyphus (Fig. 29) these two veins retain their primitive position, extending nearly parallel and ending remote from

each other at the margin of the wing. In Thereva (Fig. 32) an approximation of the ends of these veins has taken place, which results in a narrowing of the outer end of cell M_3. In

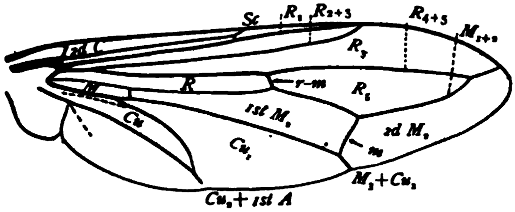

Fig. 35. — Wing of Conops.

Eulonchus (Fig. 33) the tips of the two veins coalesce, and cell M_3 is thus closed. In Pantarbes (Fig. 34) the two veins coalesce for the greater part of their length, and cell M_3 is completely obliterated.

The coalescence of veins Cu2 and 1st A.—The second branch

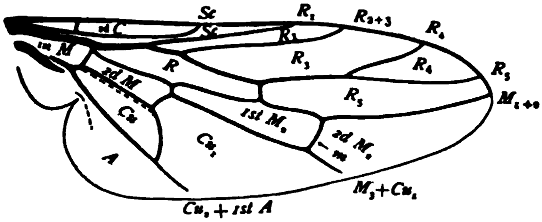

Fig. 36. — Wing of Scenopinus.

of the cubitus and the first anal vein may also coalesce in varying degrees. In Rhyphus (Fig. 29) these two veins retain their primitive position. In Leptis (Fig. 30) the tips are ap-

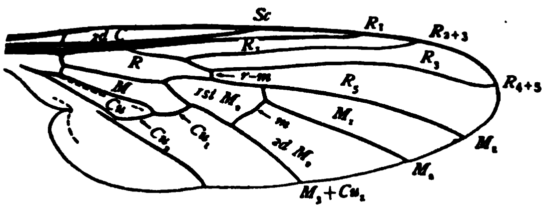

Fig. 37. — Wing of Rhamphomyia.

proximate. In Thereva (Fig. 32) the tips coalesce for a short distance. In Conops (Fig. 35) the coalescence is more striking. In Scenopinus (Fig. 36) it is carried still farther. While

in Rhamphomyia (Fig. 37) it has proceeded so far that vein Cu_2 extends towards the base of the wing, and presents the appearance of a cross-vein.

It is not strange that the homology of the branches of the cubitus in forms like Rhamphomyia was not understood until the method of study used here was employed, but now there is no doubt regarding it.

The independent specialization of different parts of the wing can be seen by comparing members of the two series given above. Compare, for example, Thereva (Fig. 32) with Pantarbes (Fig. 34). If one were to consider only the degree of coalescence of veins Cu_2 and *1st A*, Thereva would be considered the more highly specialized of the two genera, for in this genus these two veins coalesce for a considerable distance, while they are still distinct in Pantarbes. But if the degree of coalescence of veins M_3 and Cu_1 be considered the opposite conclusion would be reached, for in Pantarbes these veins coalesce for the greater part of their length so that cell M_3 is completely obliterated, while in Thereva these veins are still distinct. No better evidence could be desired for showing the impossibility of arranging animals in a natural linear series. And it is not too much to hope that an exhaustive study along these lines will serve to determine the phylogeny of the families of this order.

ENTOMOLOGICAL LABORATORY,
CORNELL UNIVERSITY, April, 1898.

CLASSIFICATION OF THE AMIOID AND LEPISOSTEOID FISHES.

O. P. HAY.

The science of ichthyology has within recent years been greatly enriched by the publication of the volumes of Mr. A. S. Woodward's *Catalogue of the Fossil Fishes in the British Museum*. This work is destined not only to give a great impetus to the study of fossil fishes, but also to have an important influence on the higher classification of the living forms. Many changes, based in part on the distinguished author's own researches, in part on the investigations of others, have been made in the ichthyological system, so that we now get new and clearer views of many groups. The author's conclusions, too, are so modestly set forth that others cannot afford to be dogmatic when they differ from him.

A large portion of the third volume of Mr. Woodward's work is devoted to the elucidation of those fishes which have for some time been regarded as forming the groups called "Amioidei" and "Lepidosteoidei." These groups are rejected by Mr. Woodward and the genera are redistributed. Catopterus and its ally Dictyopyge are made a family of the Chondrostei, while Pholidophorus and a number of related genera are removed to the Isospondyli. With this disposition of these forms no one will probably find fault.

The remaining materials are then divided into two suborders, the Protospondyli and the Aetheospondyli. The living representative of the former group is Amia; that of the latter is Lepisosteus. Mr. Woodward says (3, p. xxii): "It is equally impossible to justify the conceptions of the groups 'Lepidosteoidei' and 'Amioidei,' most of the extinct fishes which are commonly ascribed to the former being proved in the catalogue to be much more closely related to the latter."

It is the purpose of the present paper to consider the correctness of Mr. Woodward's disposition of the fishes here referred to.

The basis for the establishment of the two new suborders is found in the condition of the vertebral axis. In both groups the notochord may or may not be persistent. In the Protospondyli, if the notochord is "more or less replaced by vertebræ, the pleurocentra and hypocentra in part of the caudal region remain distinct even when fully developed." In the Aetheospondyli, on the other hand, we find the "pleurocentra and hypocentra usually fused, never forming alternating disks or rings." In fact, in all the genera admitted to the latter suborder this fusion of vertebral elements has occurred, while all genera devoid of what are regarded as pleurocentra and hypocentra, or, possessing them, do not have them fused, are relegated to the Protospondyli. That is, there are no Aetheospondyli with distinct pleurocentra and hypocentra. Furthermore, two genera which technically belong to the Aetheospondyli are referred justly, no doubt, to the Protospondyli. These are Histionotus and Neorhombolepis. We have no evidence whatever presented that they possess, even in the tail, distinct and alternating pleurocentra and hypocentra.

A word may be permitted at this point regarding relation of the pleurocentra and hypocentra to the notochordal sheath. Mr. Woodward constantly speaks of these elements as being developed in the sheath of the notochord.[1] This, so far as the Teleostomi are concerned, is an error, as has been demonstrated by the observations of many investigators. In the elasmobranchs the vertebral centra are formed principally from cartilage which has invaded the inner sheath of the notochord, and this cartilage may undergo extensive calcification. The same appears to be true of the vertebral axis of the Dipnoi. In the Teleostomi no cartilage develops within the notochordal sheath; neither do the ossifications of the vertebral centra originate there. If the sheath ever becomes ossified it is a secondary process.

It is evident that Mr. Woodward regards as a pleurocentrum any ossification in or in contact with the dorsal portion of the notochordal sheath. He would probably further limit the definition to ossifications arising distinct from the bases of the

[1] See pp. 80, 132, 164, 190, 195, 287, 374.

neural arches. Any similar ossification on the ventral side of the notochord would, I suppose, be regarded as a hypocentrum. At least, no other elements are mentioned as occurring and taking part in the formation of the vertebræ. It is nevertheless true that other elements do exist, and in many fishes enter into the construction of the definitive vertebral centra. These elements, known in their primitive condition as intercalated cartilages, are present in Acipenser and in Polyodon and remain permanently distinct.

In my investigations on the vertebral column of Amia,[1] I showed that these intercalated elements are of the greatest

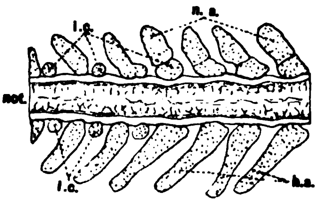

Fig. 1.

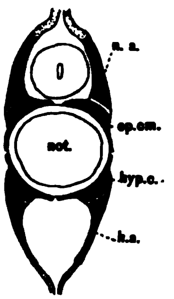

Fig. 2.

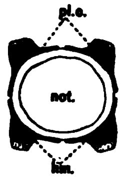

Fig. 3.

Fig. 1. — Longitudinal section of vertebral axis of young Amia, taken a little to one side of the mid-line. *i.c.*, intercalated cartilage; *n.a.*, neural arches; *h.a.*, hæmal arches; *not.*, notochord. At the right hand of the figure the upper intercalated cartilages have pushed themselves under and support the neural arches. In this region, also, the lower intercalated cartilages are wanting. The figure is from a section in the tail where vertebræ of the ordinary form change to those consisting of two distinct rings.

Fig. 2. — A diagrammatic section across one of the arch-bearing vertebral rings of the tail of young Amia. The dotted areas represent cartilage; the black represent the layer of bone covering the underlying cartilage. *ep.cm.*, the epicentral ossifications; *hyp.c.*, the hypocentral ossifications; *n.a.*, neural arch; *h.a.*, hæmal arch; *not.*, notochord.

Fig. 3. — A diagrammatic section through one of the archless vertebral rings of young Amia. *pl.c.*, pleurocentral ossifications; *hm.*, hæmacentral ossifications. Union of the four ossifications will produce a complete ring.

importance in the formation of the adult vertebral centra. I discovered that in the tail region there are, for each muscular segment, eight cartilages, *viz.*, the bases of the two halves of the upper arch, the bases of the two halves of the lower arch, a right and a left upper intercalated cartilage, and a right and a left lower intercalated cartilage (Fig. 1). At a certain stage ossification starts on the surface of each of these cartilages.

[1] Publications of Field Columbian Museum, *Zool. Ser.*, vol. i, No. 1.

Those ossifications starting from the bases of the arches, upper and lower of each segment, extend themselves (Fig. 2) and finally unite and form a ring of bone around the notochord, and lying outside of its sheath. This ring is the so-called "hypocentrum," supposed hitherto to arise from the upward growth of elements situated on the lower side of the notochord. The ossifications connected with the four intercalated cartilages (Fig. 3) spread until they meet, and thus produce another ring of bone around the notochord, the so-called "pleurocentrum," hitherto held to be the product wholly of elements situated on the upper side of the notochord. It thus becomes evident that each of the two rings of the muscular segment has another pair of elements entering into its composition besides the pair usually attributed to it. It may further be seen that the element which develops from the bases of the upper arch, the epicentrum, may easily be mistaken for the true pleurocentrum, which in reality has its origin in the upper intercalated cartilages.

In the abdominal region of Amia I found that the lower intercalated cartilage is apparently wanting. On the other hand, the upper ones, which give rise to the pleurocentra, become greatly expanded, push themselves under the bases of the upper arches immediately behind, and suppress the ossifications that might be expected to arise there (Fig. 4). The pleurocentra thus come to support the upper arches, and, growing downward, coalesce with the up-growing hypocentra to form the completed vertebral centrum. It will be seen that in Amia there are three kinds of vertebral rings, *viz.*, those formed from the union of the bases of the upper arches with the bases of the lower arches, those from the intercalated cartilages, and those partly from bases of lower arches and partly from the upper intercalated cartilages.

FIG. 4. — Section through an abdominal vertebra of young Amia, 23 mm. long. *h.a.*, base of hæmal arch = hypocentrum; *pl.c.*, pleurocentrum bearing the neural arch, *n.a.*

Now, how does ossification take place in the vertebral column of Lepisosteus, the living representative of the Aetheospondyli? Certain stages have not yet, so far as I am aware, been worked

out, but enough seems to be known to enable us to reach fairly good conclusions. It appears that in an early stage the notochord with its sheath becomes surrounded by a tube of cartilage.[1] The bases of the upper and the lower arches are continuous with this tube (Fig. 5, *h.a.*). Midway between the bases of the successive arches the tube becomes thickened into a ring (Fig. 5, *i.c.*), while on each side, just between the base of each upper arch and that of the corresponding lower arch, there is a gap in the cartilaginous tube. Now, it appears to me quite certain that the thickened ring of cartilage is composed of the four coalesced intercalated cartilages; and Dr. Gadow and Miss Abbott entertain the same view.[2] The tube is produced by the coalescence of these with one another and with the bases of the arches. When ossification sets in, the bony centers spread over the cartilage, probably from the bases of the arches, and, forming a ring, bind the arcualia of each segment together. No separate ossifications develop in the rings of intercalated cartilages, but these become divided each into an anterior and a posterior half, the anterior half forming the posterior end of the vertebra in front, the posterior half the anterior end of the vertebra behind. In Lepisosteus, therefore, the vertebral elements derived from the bases of the arches gain complete ascendency over the intercalated elements; in Amia, at least, the upper intercalated elements remain distinct and take a prominent part in the formation of the centrum.

FIG. 5. — Horizontal section through notochord of young Lepisosteus. After Balfour. Cartilage is dotted, the bone shown by heavy black lines. *h.a.*, the bases of the hæmal arch. *i.c.*, the ring of coalesced intercalated cartilages. They are represented as undergoing transverse division.

There is nothing to indicate that the vertebral rings of any of the genera assigned by Mr. Woodward to the Aetheospondyli have had a mode of development essentially different from that

[1] Balfour and Parker, *Development of Lepidosteus*, Mem. Ed., vol. i, p. 785, pls. xli, xlii.

[2] *Phil. Trans. Roy. Soc.*, vol. clxxxvi, p. 214, 1895.

of our Lepisosteus. Their vertebral centra have probably been produced by the fusion of the ossifications arising in the upper arches with those of the lower arches. We do not need to disturb these genera.

Among the Protospondyli we find the nearest allies of the Amiidæ in the family Eugnathidæ. Here we discover abundant evidences of the presence of true pleurocentra. They are shown to be such by the varying positions of the neural arches on them. Neural arch and epicentrum, being ossified portions of the same arcuale, to use Gadow's convenient term, remain in direct contact, even when not coössified. When the epicentrum

FIG. 6. FIG. 7. FIG. 8.

FIG. 6. — From tail of Eurycormus. After Zittel. Shows the arch-bearing rings formed by union of epicentra, *ep.c.*, and hypocentra, *hyp.c*; also the archless rings formed by union of pleurocentra, *pl.c.*, and hæmacentra, *hm.*

FIG. 7. — From abdominal region of Eurycormus. After Zittel. Hæmacentra wanting.

FIG. 8. — From abdominal region of Callopterus. After Zittel. Both hæmacentra and epicentra are aborted, leaving only the pleurocentra, *pl.c.*, and the hypocentra, *hyp.c.* This represents one stage in the abdominal region of Amia.

is not developed, the pleurocentrum may wholly or only partially push itself under the arch. Whenever we find two distinct rings for each segment, the upper and the lower arches are connected with the same ring, as shown in Fig. 6, which represents the vertebræ in the tail of Eurycormus. In the abdominal region of Eurycormus the arch-bearing ring is apparently complete and carries the arches, while the pleurocentra are wedged in between them (Fig. 7); but the hæmacentra, which make up the lower half of the archless rings in Fig. 6 (*hm.*), are wanting. A little further reduction of the epicentra leads to the condition found in Callopterus (Fig. 8) and some of the species of Caturus. We may be sure that species of Caturus which have not yet revealed ossified vertebral elements nevertheless possessed these elements in some form, though possibly only

feebly ossified. Among the Macrosemiidæ, as we are informed, Ophiopsis possessed "completed annular pleurocentra and hypocentra, alternating in the caudal region." These are doubtless true pleurocentra. Mr. Woodward has presented a figure of a portion of the vertebral column of Notagogus.[1] This closely resembles that of the young Amia, as shown by my own figures (Figs. 1–4). Histionotus is not represented as possessing distinct pleurocentra and hypocentra; but the figure in Dr. Zittel's *Handbuch* (vol. iii, Fig. 231) shows each of the vertebral rings as having an oblique position, as though alternating component elements had united. Compare this figure with that of Callopterus, *Handbuch*, p. 231, Fig. 243.

In the Pachycormidæ the vertebral elements are feebly developed; at most, feebly ossified. Nevertheless, they are present in Euthynotus. If we may rely on Dr. Zittel's figure of the vertebral column of this genus, the arch-bearing rings were nearly complete; but there were small pleurocentra wedged in between them.

Taking all things together, we cannot doubt that the vertebral axis of the Amiidæ, the Eugnathidæ, the Macrosemiidæ, and the Pachycormidæ conforms to the same plan of development, and that this is quite different from that of the Lepisosteoid series.

When we come to examine the vertebral structures of the Semionotidæ and of the Pycnodontidæ, we find a very different condition. In many genera, indeed, the vertebral elements are as feebly developed as in some of the Eugnathidæ. In Lepidotus, however, vertebral rings are present; but there are no evidences of the presence of two rings for each muscle segment in any part of the vertebral column. Mr. Woodward states that the rings of Lepidotus seem to consist each of four sectors, each of which bears an arcuale. That is, they are just such rings as those which bear the arches in the tail of Amia (Fig. 2) and such as occur in Lepisosteus. We find no proofs in any member of the family that the intercalated cartilages were ossified, or that they manifested any tendency to assume special importance.

[1] *Catalogue*, vol. iii, pl. iii, Fig. 10.

I do not see how, in the pycnodonts, the expansions of the neural and hæmal arches can be regarded as essentially different from the epicentra and hypocentra of the tail of the young Amia. They are indeed continuous with the corresponding arches; but so, too, are the vertebral centra of many other fishes. We do not know that the ossifications of the arches of Lepisosteus are at any time distinct from the central ring. That the superior expansions lying upon the notochord of the pycnodonts are continuous with the upper arches is evidence that these expansions do not originate from pleurocentra. The intercalated elements appear to have been suppressed or nearly so, since the bases of the arches in some genera are suturally connected, thus contributing to the rigidity of body of these remarkable fishes.

I conclude, therefore, that we have here two distinct series of fishes to deal with. In the one series the intercalated elements are never of special importance and do not form distinct ossifications. The vertebral centra, when developed, arise principally or altogether from coalescence of the bases of the upper and the lower arches. This series will include the Semionotidæ, the Pycnodontidæ, the Lepisosteidæ, and the Aspidorhynchidæ. The other series will contain those fishes in which there is an evident tendency for the pleurocentrum to usurp the place and function of the ossifications that should arise in the bases of the upper arches. This series will embrace the Macrosemiidæ, the Eugnathidæ, the Amiidæ, and the Pachycormidæ. That is, I believe that Mr. Woodward has gone too far in his transference of genera from the Lepisosteoid to the Amioid series.

As regards the systematic value and kinship of the two groups, it seems to me that they rank no higher than suborders of a distinct order of Actinopterygia. The two suborders are more closely related to each other than to the Chondrostei, or even to the Isospondyli, although the latter order has probably taken its origin from the Amia-like fishes.

I believe that the characters on which my groups of these fishes have been founded indicate two very distinct lines of development, and lines of such a nature that when once entered

on there could have been no passage across from the one to the other. Mr. Woodward's groups appear to be based on characters which are rather degrees in the development of the vertebral rings; and, indeed, Amia, a protospondylous fish, would, according to the definitions given, belong to the Aetheospondyli had the fusion of "pleurocentra" and "hypocentra" been carried out a little further in the tail.

In both of the groups proposed there are genera in which, so far as we now know them, the tendencies of the vertebral elements had as yet hardly made themselves manifest. The Lepisosteoid series has, in its vertebral structures, remained closer to the primitive condition; and its members are, therefore, rather more "protospondylous" than those of the other group.

It may be permitted me in conclusion to correct an unfortunate error that I made in a paper contributed to the *American Naturalist*, vol. xxxi, p. 402, 1897. I there stated that the arches, neural and hæmal, originate at a later period in the development of the young fish than do the intercalated cartilages. They are developed earlier, and the error was due to a slip of the pen.

U. S. NAT. MUSEUM,
March 22, 1898.

EDITORIAL.

A Plea for Systematic Work. — The systematist is under a cloud. At the biological station the naturalist of extensive acquaintance with species is looked upon with disdain by the budding zoologist still flushed with the pride of receiving his bachelor's degree. The systematist is considered a relic of a bygone age; a man who through lack of proper advantages is unequipped to do the superior class of work required in morphology and embryology. The new biologist, nurtured on "types," is quite contented if he labels the eggs he has collected "nudibranch" or "shrimp." If he descends to specific names, our eastern crayfish is, for him, "*Astacus fluviatilus*," and any frog is "*Rana esculenta*." Thus the reaction from the work of the species monger has led to carelessness of specific names.

Now, this is all wrong. Nothing is better known than that related species may differ considerably in morphological and physiological characters. When studies of such characters, made on unknown species, are published, they are apt to form the basis of profitless disputes due to the fact that, unwittingly, different species have been used by two or more investigators. Moreover, this neglect of specific characters leads to superficial observations, as a result of which facts of œcology and adaptation to environment go unobserved. Also, the scientific study of variation and the origin of species depends upon the observation of individual and specific characters, so that the present disregard of species is hindering the development of this new field of investigation.

One great obstacle to systematic work is partly responsible for the present neglect of such work. This is the fact that our species, particularly our marine invertebrates, are inadequately described. Even in the case of the groups which have been studied, the descriptions of species are scattered in a score of journals and separate publications, so that one cannot hope to have all at hand when one wishes to determine a form. Check-lists, however useful to determine distribution, do not meet the needs of the naturalist. Synoptic works, doing what Gould and Binney's work has done for the Mollusca of our northeastern coast, are needed likewise for other groups. Such works, which require for their highest usefulness figures of

every species and keys for their rapid determination, necessitate a thorough revision of large groups. The need of such synopses calls loudly upon the young naturalist to turn part of his attention from embryology and histology to first-class systematic work.

The reward will be worth the effort. The results are of permanent value. The demand for systematic books continues for generations after they have been published; they are always looked back to for synonymy and priority; they are not forgotten. Good synopses of species will also have their immediate value for every worker at the seashore. Thus, with the prospect of gaining permanently valuable results, and with the assurance of affecting the progress of a precise knowledge of animals and plants, and especially of paving the way for the phylogenetic studies of the dawning future, it becomes the duty and the privilege of the naturalist of to-day who is fitted for the work by preference or training to turn his attention to the more perfect description and illustration of our native fauna.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Social Organization of the Kwakiutl Indians.[1] — The results of the investigations made by Dr. Boas during the last ten or twelve years among the Indians of the Northwest coast have been published in the reports of the British Association for the Advancement of Science, in the *Zeitschrift für Ethnologie*, and in government reports and elsewhere in this country. The present account of the social organization and the secret societies of the Kwakiutl tribe is one of the most valuable papers in the series. The Jessup Expeditions, which Dr. Boas last year led in person, are again at work in that region, and we may expect to receive a final and complete account of these coast tribes at an early day.

It is generally known that these people form, as Dr. Boas states, a distinct cultural group; they have been isolated to some extent by mountain barriers from the tribes of the interior.

This isolation, however, has not been so complete as to prevent the introduction of myths from foreign sources. As elsewhere, culture and environment are closely related. The contour of the coast, indented by fiords and protected by islands, has favored the development of navigation. Fish and marine mammalia abound in the sheltered waters. A mild climate of extreme humidity has produced a plant growth of almost tropical luxuriance. The quest for food is one requiring such little concern that the people have abundant leisure for the development of an extensive oral literature and elaborate ceremonials. These tribes are blanket Indians in more than one sense; they are clothed in blankets, and their property consists of stores of imported woolen blankets. A blanket is valued at fifty cents, which is also the conventional equivalent in Canadian money of the "skin," the standard of value of the Athabascans of the Far North.

Among the interesting conclusions reached in this paper may be mentioned the belief of the author that in the olden times the

[1] Boas, Franz. The Social Organization and the Secret Societies of the Kwakiutl Indians. *Ann. Rept. U. S. Nat. Mus., 1895*. Washington, Government Printing Office, 1897, pp. 311–738.

Kwakiutl lived in a series of village communities in which descent was reckoned in the male line. Each clan "developed a clan tradition which was founded on the acquisition of a manitou by the mythical ancestor, the manitou becoming heredity in the clan." This manitou became attenuated to a crest which no longer descended in the male line, but may be given in marriage so that it descends upon the daughter's children. The nobility includes only the heads of families who personate the mythical ancestor.

Dr. Boas declares that the custom of the potlatch, which has been frequently described, has been thoroughly misunderstood by most observers. "The underlying principle is that of the interest-bearing investment of property." Strenuous efforts are made to acquire a fortune by imposing loans which bear a ruinous rate of interest upon friends and thrusting them upon rivals.

The authentic record of the traditions and the detailed account of the ceremonies of the secret societies, with the native nomenclature, furnish valuable material for comparative studies and lay bare to us the thoughts of this group of aborigines. It is usually much easier to collect the totem post which stands before the door than to correctly record the myth which accounts for the character of that house post. Frequently the ritual is accounted for by several myths, and is therefore presumed to be older than the myths. The secret societies, by whom the rites are performed, are believed to have originated from the habits of warfare.

The work is profusely illustrated and many songs and texts are given.

The Graphic Art of the Eskimos.[1] — In an abundantly illustrated paper, Dr. Hoffman has described the graphic art of the Western Eskimos, and has shown that the Eskimos east of Point Barrow "exhibit but little artistic expression, this being chiefly confined to lines, dots, and other similar rudimentary markings which are employed almost wholly for decorative purposes." The evidence that has been accumulated proves pretty conclusively that the modern Eskimos of Western Alaska, among whom artistic expression in graphic delineation has reached its highest development, have learned to carve and etch with steel tools under the instruction of the Russians. This disposes of the theory which derives the Eskimos from the cave dwellers of Europe.

[1] Hoffman, W. J. The Graphic Art of the Eskimos. *Ann. Rept. U. S. Nat. Mus., 1895*, pp. 739–968.

The work follows along the lines of the author's previous publications relating to the pictographs of the American aborigines, and includes an account of these records and of the gesture signs in use among the Eskimos. The subject is treated comprehensively, with many comparisons to other culture groups. F. R.

GENERAL BIOLOGY.

Chemical Changes in Plant Stimulation.[1] — Hitherto we have had no test of the stimulation of a sensitive, responsive plant organ except the response itself. Czapek himself has been able to find in the terminal perceptive cells of the geotropically stimulated root no change in the protoplasm or cell sap, no visible movements in the mass, no secretory processes, no negative variation of the electric current such as the stimulated nerves of animals show, no change in osmotic cell pressure, no change in the normal, slightly acid, reaction.

The new find is a chemical change in the protoplasm. When the root-tip of a seedling of a bean or other species is boiled in an ammoniacal silver nitrate solution, there is a marked reduction of the silver, especially in the cells of the periblem. This reduction is stronger in the cells of stimulated than in those of unstimulated root-tips.

A second change consists in the diminution in the amount of a substance of the root-tip which easily loses oxygen. Such a substance is indicated in the normal root-tip by such changes as these: blue coloration (oxidation) of a section of the root-tip by an emulsion of guajac gum in water; deep blue coloration of sections by indigo white, made by careful reduction of indigo carmine by dilute hydrochloric acid and zinc; strong violet reaction (indophenol reaction) in sections subjected to an aqueous solution of α-napthol, to which paraphenylendiamin has been added. Now, all such reactions are less marked in the root after stimulation. Thus, stimulation results in increased capacity for reduction and diminished capacity for oxidation — an increased avidity for oxygen.

These changes occur long before the response of turning shows itself, occur earlier the more sensitive the root, and are less marked after a slight stimulus such as results from a slight inclination of the root from verticality.

[1] Czapek, F. Ueber einen Befund an geotropisch gereizten Wurzeln. *Ber. deut. bot. Ges.*, Bd. xv, pp. 516–520. January, 1898.

The isolation of the two substances — the reducing and the oxidizing — was now attempted. The former is not changed by boiling or by the action of chloroform, and is soluble in alcohol; the latter is destroyed by heat, is unchanged by chloroform, is insoluble in alcohol, and can be extracted from the triturated cells by water. A large number of root-tips of *Vicia faba* were first rubbed up with water until no fragments remained. The aqueous extract was filtered, and to the filtrate alcohol was added. A precipitate was formed which had all the properties of the oxidizing substance. It is highly probable that it belongs to the category of oxidation ferments. To get the reducing substance, the preceding solution was filtered to eliminate the alcoholic precipitate. The filtrate had all the properties of the reducing substance. A further study indicated that it belonged to the aromatic organic substances, many of which have an intense reducing action, and are hence used in photography.

Thus, geotropic stimulation of the root-tip produces chemical changes leading to the increase of a reducing substance of aromatic nature, and to a diminution in the amount of an oxidizing ferment.

Dissimilar Reciprocal Crosses. — It has been observed in many cases that the two hybrids A♀ × B♂ and B♀ × A♂ are dissimilar. In the current Heft of the *Jenaische Zeitschrift* is an interesting note by the late Fitz Müller-Desterro, serving to explain this phenomenon in a single case, the hybrid of *Ruellia formosa* and *R. silvaccola*. The parent flowers differ in that those of *R. formosa* are a dark, luminous red, while those of *R. silvaccola* are a clear, faint red. The hybrid *R. silvaccola* ♀ × *formosa* ♂ is of a beautiful red, more like the red of *R. formosa* than of *R. silvaccola*; and *R. formosa* ♀ × *silvaccola* ♂ is of a cloudy mixed color, with more or less extensive smutty blotches. The difference of color is due to the fact that the egg cell only, and not the male cell, transmits the chromatophores upon which the color depends; hence, the hybrid *R. silvaccola* ♀ × *formosa* ♂ received chromatophores from *silvaccola* only, while *formosa* ♀ × *silvaccola* ♂ received them from *formosa* only. (This result does not, however, fully explain the observed facts of color in the hybrid.) The important conclusion is now drawn that in this case the qualities of the hybrid depend, not alone on the germ plasm in a strict sense, but also on certain living included particles.

Scientific Agriculture. — One of the most handy books of reference which has appeared of late is Henry's *Feeds and Feeding*.[1]

[1] Henry, W. A. *Feeds and Feeding.* A handbook for the student and stockman. Madison, Wis., 1898. Published by the author. 8vo, vi + 657 pp.

Professor Henry, who is one of the ablest and most influential Experiment Station Directors in the country, treats his subject under three headings, dealing respectively with plant growth and animal nutrition, feeding-stuffs, and feeding farm animals. From his own large experience, and the voluminous literature of the Experiment Stations, he has compiled in a readily accessible but condensed form much information concerning the transmutations which organic matter undergoes from its origin in the leaves of plants to its return to the soil as vegetable or animal refuse. T.

ZOOLOGY.

The Sea Otter.—Among North American mammals doomed to practical extermination must be included the sea otter (*Latax lutris*), unless the most rigid restrictions be speedily enforced for its preservation. Formerly this animal was more or less abundant along nearly the whole Pacific coast of North America, from the Pribilof and Aleutian Islands south to northern Lower California. Indeed, the islands of southern California and northern Lower California were, about the beginning of the present century, famous hunting grounds for the sea otter. Another portion of the seaboard where great numbers were killed was the coast of Oregon and Washington, where many were taken as late as 1876. Thence northward, also, to the Aleutian Islands they were killed in large numbers for many years. Only small remnants here and there, however, at present exist along this whole stretch of coast, their extermination, from a commercial point of view, having long since been accomplished. Even in Alaskan waters, during the last half of the eighteenth century, their indiscriminate slaughter had so far reduced their numbers that toward the close of this period the then newly formed Russian American Company placed restrictions upon the number allowed to be taken, and enforced other regulations by which the females were spared, and care insured against needlessly alarming these exceedingly timid and suspicious animals. The early wholesale, unrestricted destruction of the sea otter exactly parallels that of the fur seals throughout their range, except where accorded government protection, and with the same sad result of practical extinction.

Their numbers have now become so alarmingly reduced, even in their last stronghold, the Aleutian Islands, notwithstanding attempted government restriction, that more serious measures for

their protection are now contemplated, not only in behalf of the sea otter, but more especially in behalf of the natives of the Aleutian Islands, who are almost entirely dependent upon the sea otter for the necessaries of life. The present status of this animal has hence been made the subject of a report[1] by Capt. C. L. Hooper, of the Revenue Cutter Service, to the U. S. Treasury Department, from which it appears that none now exist on the islands or shores of the mainland north of the Alaskan Peninsula; at least the animal is not now hunted outside of the Aleutian Islands. Captain Hooper states that no reliable record of the sea-otter catch is obtainable prior to 1873. He presents, however, a tabular statement of the approximate number taken annually at the different islands by the natives from 1873–96 inclusive. The total catch for this period of twenty-four years is about 58,000, the largest number, 4152, being taken in 1885, and the smallest, 598, in 1894. This does not, however, include the considerable number killed by white hunters which yearly visit the otter banks. It is, however, a trifling number in comparison with the annual catches of a century ago.

Under this constant persecution the sea otter has not only greatly decreased in numbers, but has notably changed its habits. To quote from Captain Hooper's Report: "Being constantly harassed, clubbed, and shot on shore, caught in nets by white men, their hauling grounds made uninhabitable by the camp fires of the hunters and defiled by fisheries and the decaying bodies of their slaughtered companions, the sea otter of the Aleutian Islands has not only decreased in numbers, but has actually changed its habits. It no longer comes out upon the land to feed, rest, or give birth to its young. A floating raft of kelp serves as its only resting place and banks of thirty fathoms of water are its feeding grounds. Even there it is hunted and harassed by hunting schooners from March until August. Having been driven from the shore, it is being exterminated on the sea by a fleet of hunting schooners, and the native hunters of the Aleutian Islands are being deprived of their chief means of subsistence. In addition to its change of habits and decrease in numbers, the range of the otter is very much reduced."

[1] A Report on the Sea-Otter Banks of Alaska, Range and Habits of the Sea Otter. — Its Decrease under American Rule, and some of the Causes. — Importance of the Sea Otter to the Natives of Alaska inhabiting the Aleutian Islands. — Proposed Regulations for 1898. By C. L. Hooper, Captain R. C. S., Commanding Bering Sea Patrol Fleet, 1897. Washington, Government Printing Office, 1897. *Treas. Depart. Doc.* No. 1977. 8vo, 1–35 pp., with map.

Captain Hooper urges the enforcement of more stringent regulations respecting sea-otter hunting, not only for the purpose of preserving "the most beautiful and valuable fur-bearing animal in the world, but to preserve it for the benefit of the natives who have been dependent upon it for more than a century, and who will be reduced to suffering and want without it."

J. A. ALLEN.

Pacific Coast Annelids. — In the recent paper[1] by Prof. H. P. Johnson, of the University of California, we have the promise of an extension of our knowledge of the marine annelids of the western coast of North America that will undoubtedly be welcomed by students of marine zoology. This first contribution deals only with five families of the order Polychæta, *viz.*, the Euphrosynidæ, the Amphinomidæ, the Palmyridæ, the Polynoidæ, and the Sigalionidæ. The scope of the work which Dr. Johnson has laid out for himself, and the beginning of the execution of which is now presented, may be stated in his own words: "It is certainly an interesting reflection of the haphazard nature of zoological exploration to find that much more is known about the Polychæta in the most remote regions of the earth, in the farthest north and the farthest south, in the East Indies and in the South Seas, than along the easily accessible shores of a great civilized nation. No apology, therefore, need be offered for the preponderance of attention here given to such preliminary matters as descriptions of new species, distribution, habits, and other details of the natural history of the group. It is the writer's intention to present the entire order Polychæta as represented on our shores thus in outline, and concurrently or subsequently to fill in the picture with as much of embryological and histological detail as possible. The present publication is in every sense a *prodromus* of a more extensive work, which will require many years to complete."

Eighteen species in all are treated in the paper, thirteen of which are new to science. They are as follows:

Euphrosynidæ : *Euphrosyne aurantiaca*, sp. nov., *Euphrosyne arctia*, sp. nov.; Amphinomidæ : *Eurythoë californica*, sp. nov.; Palmyridæ : *Chrysopetalum occidentale*, sp. nov., HETEROPALE, gen. nov., *Heteropale bellis*, sp. nov.; Polynoidæ: POLYNOË Savigny (Sens. ext.) (including *Lepidonotus* Leach, *Polynoë* Savigny, and *Halosydna* Kinberg), *Polynoë squamata* (L.) Aud. et M.-Edw., *Polynoë brevisetosa* Kinberg, *Polynoë*

[1] Johnson, H. P. A Preliminary Account of the Marine Annelids of the Pacific Coast, with Descriptions of New Species. *Proc. Calif. Acad. Sci.*, Ser. 3, zool., vol. i, No. 5, 1897, pp. 153–190, Pls. V–X.

reticulata, sp. nov., *Polynoë gigas*, sp. nov., *Polynoë lordi* Baird, *Polynoë pulchra*, sp. nov., *Polynoë fragilis* Baird; HARMOTHOË Kinberg (Sens. ext.) (including *Antinoë*, *Harmothoë*, *Hermadion*, Kinberg; *Eucrante*, *Eunoa*, *Evarne*, *Lænillà*, *Lagisca*, *Melænis*, *Nychia*, Malmgren; *Polyeunoa* M'Intosh): *Harmothoë imbricata* (L.) Malmgren, *Harmothoë hirsuta*, sp. nov., *Harmothoë crassicirrata*, sp. nov.; Sigalionidæ: PEISIDICE, gen. nov., *Peisidice aspera*, sp. nov., *Sthenelais fusca*, sp. nov., *Sthenelais verruculosa*, sp. nov.

Concerning the classification of the polynoids, the author tells us that he has been strongly tempted to follow the more conservative students of the group and place the forms he has studied all under the type genus Polynoë; but that, after a careful study of the material at hand and the literature available, he has become convinced of the practicability of arranging nearly all the known species under two genera, *viz.*, *Polynoë* Savigny and *Harmothoë* Kinberg. He wishes it to be fully understood, however, that he regards this as provisional only.

Collections have been made at numerous points, from San Diego on the south to Puget Sound on the north. Most of the species have been collected by the author himself, and have been studied in the living condition.

Numerous interesting observations on the habits and variability of several of the species are recorded, none of which are more interesting, perhaps, than those pertaining to the commensalism exhibited by some of the species of the genus Polynoë. Thus we are told concerning *P. brevisetosa* that "probably no species of this great family, noted for the morphologic plasticity of many of its members, is more variable than this. The variation it exhibits is unquestionably due to differences in its environment." Some of the individuals are free living, while others are commensal in the tubes of species of Amphitrite and Thelepus. "Like another tube-commensal of our coast, *Polynoë reticulata*, it attains a larger size in this mode of existence than when free living, but not unless it lives in a tube of liberal dimensions, so that both the rightful occupant and its messmate have ample space." The commensal individuals are said to be proportionally longer and narrower than the free-living ones, and furthermore to exhibit certain structural peculiarities, most of which appear to be the direct result of their mode of life. The elytra are thinner and smoother, and not so likely to extend to the extreme posterior end of the body. And, what is still more significant, the elytra of the ventral series tend to develop a strong upper bristle, which the author thinks is of advantage in crawling into the tube. A very curious thing in

connection with the commensals of this species is the fact that the pigment is heavier and more uniformly distributed in them than in the free-living individuals. In another species, however, *viz.*, *P. pulchra*, which lives "as a common messmate (or possibly parasite) of two animals wide apart in the organic scale, *Holothuria californica* and *Lucapina crenulata*," the wholly hidden specimens may be destitute of pigment.

Polynoë gigas the author finds to be almost always asymmetrical in the arrangement of the elytra and dorsal cirri. Of nine specimens examined, only three had the same number of elytra on each side; and of these three, only one was fully symmetrical. W. E. R.

Regeneration of the Earthworm's Head. — Of late there has been a noticeable revival of the old interest in problems of regeneration of lost parts in animals, but it has been rather striking that so many observers have been content to use only the old methods available before the present era of microtome and perfected staining technique. In contrast to them comes the second part of the investigations of Dr. K. Heschler,[1] who studies by serial sections the newly forming heads in nearly one hundred earthworms from which the first four or five segments had been cut off.

Some of the results obtained are briefly noted below, but it should be kept in mind that the author does not claim to have exhausted the most difficult question of the histology of regenerating organs in the earthworm, and that he freely concedes that the interpretation of the confused and complex masses of tissue we find in these regenerating heads has a large subjective element.

During the first week after the removal of the head there is but little actual regeneration of parts. The wound heals by the formation of a cicatrix that is made up chiefly of lymph cells; but after a few hours spindle-shaped cells of undetermined origin are added to it. The epidermis grows over this cicatrix in a few days, while the intestine closes up and draws back so that the cicatricial tissue lies between its blind end and the new epidermis.

After this first period there is active regeneration accompanied by mitotic cell division. New cells — "regeneration cells" — wander into the cicatrix from epidermis, muscle, and other sources. In the complex mass so formed the new nervous and digestive organs of the head now arise.

[1] Ueber Regenerationsvorgänge bei Lumbriciden, II. *Jenaische Zeit. f. Naturwissenschaft.* März, 1898. Pls. XXI–XXVI, pp. 521–596.

The ventral nerve cord grows forward into the above mass as nerve fibers accompanied, probably, by some cells from the old cord. It is interesting to note here that the entire cord, at least as far back as the fifteenth segment, shows most active mitotic divisions of ganglion as well as of other cells. To this forward growth from the old cord is added a collection of many cells that migrate in, separately, from the new epidermis that grew ovèr the cicatrix. These cells furnish the main part of the new brain.

The new epidermis over the cicatrix grows backward as a small funnel, which meets the old intestine as it elongates into the new tissue. The ingrowth ultimately opens into the old intestine and is thought probably to form the digestive tract in the new head as far back as the fourth segment, where the new pharynx will be formed from the old intestine.

The making of a new head in the earthworm thus involves elongation of old organs, transformation of some of them, and in the case of the nervous system marked change of activity even in parts remote from the wound; in addition there is a large element of new formation from cells of an embryonic and undifferentiated character.

E. A. A.

Two Papers on the Finer Structure of Nerve Cells. — Students of neurology are indebted to Prof. A. van Gehuchten for an excellent *résumé*[1] of the more recent work on the finer structure of the nervous cell. The paper was prepared as a report for the Twelfth International Congress of Medicine, held at Moscow in August, 1897. After a brief introduction the subject is dealt with in four chapters as follows: the internal organization of nervous cells, changes which accompany their different states of activity, changes from lesion of the axis-cylinder process, and changes from disturbances in the circulation and from poisons. The paper is illustrated by one plate, and the numerous bibliographical references are gratifying. It is to be regretted that the medical influence has asserted itself to such an extent that the report treats almost exclusively of the nervous cells of vertebrates.

Prof. C. F. W. McClure[2] has undertaken the study of the finer structure of the nerve cells in the invertebrates on lines inaugurated

[1] Gehuchten, A. van. L'Anatomie fine de la cellule nerveuse. *La Cellule*, tome xiii, pp. 313-390, 1897.

[2] McClure, C. F. W. The Finer Structure of the Nerve Cells of Invertebrates. I. Gasteropods. *Zool. Jahrb., Abt. f. Anat. u. Ontog.*, vol. xi, 1897.

for the vertebrates chiefly by Nissl, and gives in the first of what promises to be a series of contributions to this subject an account of the nerve cells of certain gastropods: Helix, Arion, and Limax. Exclusive of nuclei, the bodies of the nerve cells in these animals are composed of an apparently homogeneous ground substance containing many small granules usually arranged in rows. From the reactions of these granules to dyes, especially to methylene blue, they are regarded as similar to the chromophilous substance in the nerve cells of vertebrates. They are often grouped in spindle-shaped masses which resemble the "Körner" of vertebrate nerve cells. Fibrillæ, which differ in their staining qualities from the ground substance as well as from the granules, are believed to occur both in the bodies of the cells and in their axis-cylinder processes. In the majority of cells the fibrillæ show a concentric arrangement. The chromophilous granules form rows on or between these fibrillæ, but are not to be regarded as thickenings in the course of a fibrilla. In Helix it is interesting to note that structures comparable to centrosome and centrosphere have been identified. G. H. P.

Forestal Zoology. — Under the title *Forstliche Zoologie*,[1] Dr. Eckstein, Docent at the Forestry School of Eberswalde, publishes a manual of zoology as viewed from the standpoint of the student of forestry, in which not only the animals themselves, but the effects that they produce on plants are described and figured.

Zoological Notes. — The Report of the U. S. Commissioner of Fish and Fisheries for the year ending June 30, 1897, recently issued, contains as an appendix of 340 pages, with 80 plates, a comprehensive manual of fish culture, based on the methods of the United States Commission.

Dr. Ludwig Plate has described,[2] under the name *Macrophthalmia chilensis*, an interesting cyclostome. This form comes from fresh water, is about three feet in length, with compressed form; bluish black above, silvery white beneath. The most important structural features appear to be the large and well-developed eyes, much like those of teleosts, and the nasal opening not at the tip of a nasal papilla. There are seven gill openings; the teeth of the oral hood are simple and more like those of Myxine than those of Petromyzon. A full anatomical description is promised later.

[1] Eckstein, Karl. *Forstliche Zoologie.* Berlin, Parey, 1897. 8vo, viii + 664 pp., ff. 660.

[2] *Sitzungsberichte d. Gesellsch. f. Naturf.* Berlin, Freund, 1897.

Dr. Franz Werner, in *Verhandl. zool. bot. Gesell. Wien*, xlviii, 1, gives an interesting summary of our knowledge regarding the breeding habits of amphibians. The author calls attention to the fact that most of the forms inhabit tropical America. A bibliography is appended.

It appears from a recent number of the *Mededeelingen van het Proefstation Oost-Java* that in that part of the world tailor birds are found to be injurious to the fields of sugar cane.

The recent discovery by Mr. James P. Hill,[1] that the marsupial genus Perameles has a true allantoic placenta, is one of the most important in regard to the mammals in recent years, possibly since the discovery of the oviparous nature of the monotremes, pointing, as it does, to the idea that the marsupials have descended from a placental stock.

BOTANY.

The Floral Plan of the Cruciferæ. — When the great number, wide distribution, and habital diversity of the Cruciferæ are considered, it is remarkable that the floral structure is well-nigh constant throughout the whole family. So uniform, in fact, are the flowers that the systematist has always been puzzled to find in them clear or satisfactory distinctions for tribal subdivision. Within a four-membered calyx are four petals, alternating with the sepals, then two short lateral stamens, two pairs of longer, somewhat approximated stamens approaching the median line, and, finally, a two-celled gynœcium with lateral valves and median "false" septum. Departures from this well-known plan are chiefly of the nature of simplification through reduction or abortion of parts.

On a casual inspection, the typical cruciferous flower would seem to be simple enough except in its hexandrous andrœcium, but its plan, even after exhaustive research and prolonged discussion, is still a matter of doubt, and each whorl of floral organs has been subject to widely divergent interpretation. Among the numerous investigators, who have published upon the cruciferous flower, may be mentioned A. P. De Candolle, Kunth, Bernhardi, Steinheil, Hochstetter, Krause, Wydler, Payer, Chatin, Godron, Eichler, Duchartre, Wretschko, Fournier, Engler, Klein, Celakowski, Chodat, and Lignier. Of these

[1] *Quar. Journ. Micros. Sci.*, vol. xl, p. 385.

writers, Eichler has, after an admirable summary of previous work upon the subject, stated the simplest and perhaps most convincing plan. His diagram, which has in recent years met with pretty wide acceptance, is as follows: the calyx consists of two dimerous alternating whorls; the corolla of a single tetramerous whorl, of which the parts alternate with the sepals taken together; the andrœcium of two dimerous whorls (the members of the inner being doubled by division), and the gynœcium of two laterally placed carpels.

This theory is too well known and has been too carefully grounded to need any explanation or defense here. In recent years, however, three more or less divergent views have been expressed by Klein, Celakowski, and Lignier. Passing over some slight points, one may say that the plan of Klein differs from that of Eichler in maintaining a tetramerous inner whorl of stamens and a four-carpelled gynœcium, in which not only the two valves, but also the two placenta-bearing columns of the replum, represent carpels. Celakowski, however, believes the andrœcium to be derived from two tetramerous alternating whorls, the outer of which has lost two of its members by abortion. He agrees with Eichler and most of the earlier writers in regarding the gynœcium as fundamentally bicarpellary.

Lignier[1] has suggested a theory of which the ingenuity is only exceeded by the disregard for facts. He supposes the flower to consist of only four alternating dimerous whorls. The first consists of the two outer sepals, which he believes lateral. Then follow the two median sepals, which he regards as three-parted, the green sepal being the central part of each and the two adjacent petals being the lateral parts or lobes of the sepals. Similarly, the short stamens are regarded merely as the middle lobes of trifid members, of which the adjacent longer stamens represent the lateral parts. Even in the gynœcium Lignier endeavors to show connate three-parted members, since he regards the placentæ as the central lobes and the valves as composed of the connate lateral lobes of two carpels!

The latest publication upon the cruciferous flower is that of Chodat and Lendner.[2]

These authors have made a detailed examination of the floral development, especially as to the course of the fibro-vascular bundles, and devote some space to a refutation of Lignier's theory, — a matter of no great difficulty for any one reasonably conversant with the early stages of the cruciferous flower. The argument is chiefly

[1] *Compt. rendus. Acad. Sci.*, pp. 675–678, 1895.

[2] *Bull. de l'Herb. Boiss.*, v., pp. 925–938, November, 1897.

to the effect that the corolla arises as a distinct whorl of organs which are formed later than the inner sepals and receive bundles which leave the axis at a higher point. In the same way the long stamens are shown to be a distinct whorl and in no sense appendages of the shorter ones.

Chodat and Lendner agree in nearly all points with the view of Klein, and argue that the seemingly bicarpellary gynœcium of the normal Cruciferæ is in reality due to the union of four carpellary members. This view is based chiefly upon the course of the bundles in certain anomalous three- or four-carpelled specimens of *Cheiranthus cheiri* L. It is scarcely necessary to say that a conclusion from these rather doubtful premises must be accepted with all due caution.

B. L. R.

Zinsser on Root Tubercles of Leguminosæ. — In *Jahrb. f. wiss. Bot.*, Bd. xxx, Heft 4, pp. 423–452, may be found an interesting paper by O. Zinsser on the root tubercles of the Leguminosæ. This paper contradicts some of the statements of Frank, Gonnermann, Laurent, etc., especially the statement that the root tubercle organism occurs outside of the tubercles in various parts of the plant. This work was done in the Botanical Institute at Leipzig. The following are some of the more important statements:

1. Seeds of all sorts of leguminous plants were washed in sterile water, soaked fifteen minutes in water containing mercuric chloride (1 : 1000), washed again thoroughly in sterile water, planted in sterile earth, covered with cotton-plugged sterile bell jars, and watered with sterile water. The plants which grew from these seeds were under observation eight to twelve weeks, but in no case did any tubercles form on their roots. If, however, the contents of root tubercles of these same plants was added to the earth, tubercles developed on the roots in most cases in fourteen days. The author believes with Prazmowski that Dr. Frank's diametrically opposite results were due to the fact that he did not succeed in freeing his seeds from adhering surface organisms. So far as could be detected, the sublimate treatment did not in any way injure the plants.

2. Other aërial parts and roots destitute of tubercles were then tested in various ways for the occurrence of the germ:

(*a*) Approved staining methods, *e.g.*, carbol fuchsin, alkaline methylen blue, gentian violet in anilin water, etc., were used on sections, but in no case could bacteria be demonstrated in the tissues.

(*b*) The author washed out the contents of tubercles in water, injected this into growing stems or roots of seedlings, and after a lapse of from four to six weeks washed their surface thoroughly with sterile water, bruised them in a sterile porcelain mortar, mixed thoroughly with sterile earth, planted therein the sterilized seeds, and obtained root tubercles in three weeks on the roots of almost every plant. This would indicate that, if the germs are normally present in the stems and other non-tuberculous parts of leguminous plants, the bruised tissues added to sterile earth ought to infect the roots of seedlings grown therein. Consequently, roots, stems, leaves, and leafstalks of *Phaseolus vulgaris*, *P. multiflorus*, *Vicia sativa*, *V. faba*, *Pisum sativum*, *Ervum lens*, and *Lupinus albus* were tested in this way after cutting away the superficial portions with sterile knives, but in no case did any root tubercles appear.

(*c*) After isolating the root tubercle organism from four plants (*Phaseolus multiflorus*, *Pisum sativum*, *Lupinus albus*, and *Vicia faba*) and determining that the cultures were able to produce root tubercles on the specified plants, and would remain alive for a long time when injected into parts above ground, attempts were made to isolate these organisms from other parts of the same plants, using four different media, *viz.*: (1) sterilized hydrant water; (2) water, meat extract, peptone, and sugar in the following proportions,—100, 0.5, 0.5, 3.0; (3) decoction of the plant mixed with washings of earth; (4) decoction of the plant, asparagin, and sugar in the following proportions,—100, 0.25, 0.5. These nutrient solutions were sterilized in small Erlenmeyer flasks. The inoculations were made in a room rendered as free as possible of floating germs by the introduction of vapor of water. The selected, above-ground tissues were washed for a long time and very carefully in sterile water, cut into small pieces with flamed shears, and put carefully into the flasks, part of which were exposed to the air and the rest subjected to an atmosphere from which the oxygen was removed as completely as possible. Bacterial growths appeared in only a few of the flasks, and none of these produced any root tubercles when added to the sterile earth in which the seeds were grown. This experiment was repeated on roots free from tubercles with the same negative result.

(*d*) When sterilized seeds had sufficiently germinated, the roots were put through a tiny opening in the bottom of a glass pot, and then the bottom of the pot was filled with a mixture of sterilized gypsum and water, so that the middle part of the roots was cemented fast. The part of the root above the partition of gypsum was then covered

with sterile earth and watered with sterile water, the part below being put into ordinary earth mixed with bruised tubercles. The whole was then protected from air infection by a glass cover. Root tubercles formed on this lower part of the root, but none were found on the root and rootlets grown in the sterile earth. Cultures from the part of the roots grown in the sterile earth and from the parts above ground yielded negative results; bruised portions added to sterile soil also failed to cause any root tubercles on the roots of seedlings grown therein. The reverse experiment was tried, *i.e.*, using infected soil in the upper chamber and sterile soil below. In this case tubercles formed on the roots in the upper chamber and not on those in the lower one. Cultures and soil infections from these lower roots yielded negative results. These experiments indicate that the germs cannot migrate from the tubercles to other parts of the plants.

3. Mr. Zinsser determined with considerable care the length of time the root tubercle organisms of *Phaseolus multiflorus* are able to live when injected into germinating seeds, young roots, young and old stems, leafstalks, etc., of various legumes. His conclusions do not differ much from results obtained by numerous observers working with all sorts of organisms non-pathogenic to plants. In other words, they were able to retain vitality and make a feeble growth for a variable period, usually two to ten weeks, but only in close proximity to the place of insertion, the germs being injected by means of a Pravaz syringe. The infectious material was derived from pure cultures and also directly from the tubercles.

4. Water washings from the root tubercles of three different legumes (*P. multiflorus*, *V. faba*, and *L. albus*) were injected into a great variety of plants (forty-two species of many different orders), but after eight weeks the organisms were not to be found in any of them either at the point of insertion or two centimeters away. Moreover, on the roots of none of these plants could tubercles be induced, although abundant washings of root tubercles were added to the earth. Pure cultures and tubercle washings from *Phaseolus multiflorus*, *P. vulgaris*, *Vicia faba*, *Lupinus albus*, and *Pisum sativum* were also injected into the callus on cut branches of locust, poplar, and willow, but after forty days no living bacteria were to be found therein.

5. The author also tried the behavior in plant tissues of a variety of micro-organisms non-pathogenic to plants, with results much like the preceding and entirely confirmatory of what we already know, namely, that many saprophytes and animal parasites are able to live

in plants for some weeks (three to ten or more in Mr. Zinsser's experiments), and frequently make a feeble growth, especially when injected in large numbers. Mr. Zinsser's experiments include ten bacteria and were made on no less than fifty of the higher plants, Leguminosæ included, unquestionably involving an enormous amount of hard work. Pure cultures were always used. These were diluted with water and injected by means of a Pravaz syringe. In all cases the growth, if any, was restricted to the immediate vicinity of the puncture. On examination, bacteria were found only in the injured cells and in the intercellular spaces, never in the uninjured living cells as a result of their own activities. The length of time the bacteria were able to live in the tissues varied with the plants, and was different for different micro-organisms. Even the most resistant spores (those of *B. subtilis*, *B. prodigiosus*, *B. megaterium*, and *B. anthracis*) died in the plant tissues inside of eighty-six days.

6. The author did not succeed in growing the genuine tubercle bacilli on agar or gelatin prepared according to Beÿerinck's direction and Gonnermann's. On such media numerous germs were obtained from the tubercles after sterilizing their surface, but they were non-infectious, and must be considered as associate forms or secondary growths (see Beÿerinck's statements). The tubercles were sterilized by soaking ten minutes in 1 : 1000 sublimate solution, or by washing thoroughly in sterile water, soaking for a few minutes in alcohol and then burning this off. After numerous failures, the true germ was finally isolated on Winogradsky's silicate jelly. In Petri dishes on this medium at the end of eight days the colonies were small and white, grew well in the juice of the host plants, and produced tubercles on their roots. Living colonies were found in anærobic cultures at the end of three weeks. The microbe is about 1 μ long, and actively motile. Neither spores nor flagella could be demonstrated. The colonies obtained from the tubercles of different plants looked just alike, and addition of plant juices to the silicate jelly did not in any way change the appearance of these colonies. The organisms were also morphologically indistinguishable.

7. Flasks of water, sugar, magnesium sulphate, and potassium phosphate in the following proportions, 100, 5.0, 0.1, 0.1, were inoculated, put in a dark place, and aërated with air from which by passage through potash water and then through sulphuric acid all nitrogen compounds were removed. After forty-nine days these

flasks were opened. No living bacteria were present in any of them, nor were the fluids able to produce tubercles when added to the roots of plants growing in sterile earth. Under these conditions the germs were not able to assimilate free nitrogen.

8. It is not clear in just what way the tubercles originate. Their production is due to the action of specific organisms, but these are not always capable of causing them, as the frequent failures showed. The author was not able to produce them by direct inoculations, not even in the tissues of young roots and stems. He thinks that possibly infection takes place only through young root hairs. Contrary to Laurent, the time of year makes no difference; neither does the age of the plant, as Nobbe has also shown, since tubercles were obtained both on the roots of seedlings and on those of well-developed plants. Gain's observation that infections are more numerous in a damp soil is confirmed. ERWIN F. SMITH.

Recent Studies of Asarum. — The wild gingers of the Eastern and Middle United States, concerning the specific definition of which some doubt has long been felt, form the subject of papers by Bicknell in the *Bulletin of the Torrey Botanical Club* for November last, Ashe in the first part of the current volume of the *Journal of the Elisha Mitchell Scientific Society*, and Kraemer in the *American Journal of Pharmacy* for March. In commenting on some of these papers in the *Journal of Botany* for March, James Britten and Edmund Baker analyze the synonymy of certain of the species and call rather emphatic attention to the desirability of consulting types in serious systematic work. Some slight bibliographic confusion is likely to result from the publication of Mr. Ashe's paper in separate form long enough before the number of the *Journal* containing it was issued to enable him to revise the latter into quite a different article. T.

Combs's Flora of Santa Clara Province, Cuba. — The island of Cuba is one of considerable interest to the botanist, as is shown by the rich collections made by many early explorers. In recent years, however, the region seems to have been neglected. We have before us a contribution of considerable length devoted to the flora of Cienfuegos, province of Santa Clara, by Robert Combs.[1] The author enumerates 713 species, of which *Caesalpinia cubensis*, *Acacia*

[1] Plants Collected in the District of Cienfuegos, Province of Santa Clara, Cuba, in 1895–1896. *Trans. Acad. Sci. of St. Louis*, 7: 393–491, pls. 30–39, one map, 1897. (Contributions Botanical Department, Iowa State College of Agric. and Mechanic Arts, No. 7.)

polypyrigenes, *Rondeletia combsii*, *Catesbaea nana*, *Anastraphia northropiana*, *Tabebuia petrophila*, and *Chloris eleusinoides*, var. *vestita*, are new. In addition to the enumeration of the species, full notes on the abundance and character of the soil on which the plants occurred are given. Œcologically, the flora may be divided into seven regions: (1) the maritime, (2) the river bottoms, (3) inland swamps or "cienegas," (4) upland woods, (5) the mountain regions, (6) the savannahs or wooded grass lands, and (7) a kind of arid, desert-like region. Each region has many typical plants. These regions, however, grade into each other; some plants occur in one or more regions. The orders Leguminosæ, Compositæ, Rubiaceæ, Euphorbiaceæ, Malvaceæ, and Gramineæ lead in point of numbers, and it is probable that the Gramineæ and Cyperaceæ are more numerous than given in the catalogue, and that the number could be considerably augmented by another season's collecting. It is to be hoped that Mr. Combs may again visit this region. The catalogue is, however, a representative one, since the collecting was done during both the dry and the wet season, the dry season, when Compositæ are most abundant, corresponding to our winter. The determinations were made by J. M. Greenman, of Cambridge, who is well qualified to speak on the Cuban flora, having previously studied the Northrop collection. The paper contains the vernacular Spanish names, and these are quite numerous because of the many uses that Cubans make of the native plants for medicinal purposes. Mr. Combs has further given a short account of Cuban medical plants in another paper.[1]

L. H. PAMMEL.

Central American Botany. — Captain J. Donnell Smith, who for a number of years has been concentrating his energy on the Central American flora, publishes his twentieth installment of descriptions of new plants from Guatemala and other Central American republics in the *Botanical Gazette* for March. One new genus, Prosthecidiscus, of the Asclepiadaceæ, is characterized and well figured.

Epiphyllous Flowers. — The knowledge of this unusual type of inflorescence, summarized by C. de Candolle[2] and Gravis[3] a few years since, is enriched by a study of *Chirita hamosa* conducted under the direction of Professor Warming, of the Copenhagen Uni-

[1] Some Cuban Medical Plants. *Pharmaceutical Review*, 15: 87–91, 109–112, 136, 1897.

[2] *Mém. Soc. de Phys. et d'Hist. Nat. de Genève*, 1890, suppl. vol.

[3] *Comptes Rend. Soc. Roy. de Bot. de Belg.*, 1891.

versity, by C. E. Boldt, the results of which appear in the *Videnskabelige Meddelelser* for 1897 of the Natural History Society of that city.

Forest Trees. — Professor Büsgen, of the Eisenach Forestry School, has recently published a handbook of information concerning the structure and life processes of forest trees,[1] which are considered as to their winter aspect, the causes of their forms, buds, tissues, wood and bark structure, annual or growth rings, formation of heart-wood, leaves, root activity, uses and source of water and mineral matters, metabolism and the transportation of food, fructification and germination. The illustrations, many of which are original, contribute materially to the elucidation of the subjects discussed. T.

The Work of Aldrovandus. — In December last the city of Bologna celebrated the opening of a hall commemorative of one of her first botanists, and the proceedings on that occasion, accompanied by an analysis of his works, form an attractive octavo pamphlet[2] which has recently been published.

Botanical Notes. — The volume of *Transactions of the Kansas Academy of Science* for 1895–96, issued in the early part of the present year, contains the following papers on botany: "Additions to the Grasses of Kansas," by A. S. Hitchcock; "Additions to the Flora of Kansas," by B. B. Smyth; "The Propagation of Erythroniums," by E. B. Knerr; and "A Provisional List of the Flowering Plants of McPherson County," by H. J. Harnly.

Dr. B. L. Robinson brings together, in the *Botanical Gazette* for March, notes extending the range of several North American species of Caryophyllaceæ which have come to his notice since the publication of the last fascicle of the *Synoptical Flora*, and adds to the flora two new species (*Stellaria oxyphylla* and *S. washingtoniana*, both from the Northwest), and two (*Arenaria uliginosa* and *Drymaria cordata*) previously described from without our range.

Under the title of "Contributions to Western Botany, No. 8" — unfortunately without evident indication of place of publication —

[1] Büsgen, M. *Bau und Leben unserer Waldbäume.* Jena, Fischer, 1897. 8vo, viii + 230 pp., 100 ills.

[2] Mattirolo, O. *L'Opera botanica di Ulisse Aldrovandi* (1549–1605). Bologna, Fratelli Merlani, 1897. 8vo, xxx + 137 pp., with portrait.

Professor Marcus E. Jones, of Salt Lake City, Utah, has issued a pamphlet of some forty-five pages octavo, in which a considerable number of species of plants are described as new to science. Having had the good fortune, as he states, to see nearly all the types of North American Astragali during the past year, Mr. Jones has not a little to say about this much-vexed genus. A round-topped Composite shrub from the Panamint Mountains of California is made the type of a new genus, close to Dysodia, under the name *Inyonia dysodioides*.

No. 7 of Professor Greene's "Studies in the Compositæ," published in part in the signatures of *Pittonia* issued Feb. 25, 1898, contains a rearrangement of the Composite genus Actinella, which, since the name is held to be invalid because it was early used in a different sense, is renamed Tetraneuris as to most of its species, and Rydbergia as to *Actinella grandiflora* Gray and its variety *glabra*. Eight species are described as new.

The *Bulletin of the Torrey Botanical Club* for March contains a paper by Professor Greene on "New Compositæ from New Mexico," in which seventeen species or varieties and one genus, Wootoria, are described as new.

The Pacific Coast Valerianellas, under the generic names Plectritis and Aligera, form the subject of a brief synopsis by Mr. Suksdorf in *Eythea* for March. One additional species, *Aligera Jepsonii*, is described.

Dr. Small contributes a thirteenth part of his studies in the botany of the Southern United States to the *Bulletin of the Torrey Botanical Club* for March. Twenty-four species and one genus, Forcipella, pertaining to the Paronychiaceæ, are described as new.

Crépin's section Minutifoliæ, of the genus Rosa, receives a second species in *Rosa stellata*, of the New Mexican region, described and figured by Professor Wooton in the *Bulletin of the Torrey Botanical Club* for March.

Lilæa, a monotypic monocotyledonous genus widely distributed through the western part of the American continent, and concerning the systematic position of which there is diversity of opinion, has been studied by Professor Campbell, whose paper, published in the *Annals of Botany* for March, leads to the conclusion that while there is not much evidence of the direct derivation of this simple type from the Pteridoplytes, there is likewise no evidence that it represents a

degraded form, the author's belief being that the simplicity of its flowers is really primitive.

In a paper in the *Videnskabelige Meddelelser* of the Copenhagen Natural History Society for 1897, Dr. V. A. Poulsen, whose work in this field extends over many years, publishes a paper dealing with the extrafloral nectaries of Excœcaria, Fragræa, Vaccinium, and Shorea.

Professor Hitchcock, who is giving more time to œcological studies than most Experiment Station botanists appear to find time for, publishes as *Bulletin No. 76* of the Kansas Station at Manhattan a well-illustrated paper on "The Vegetative Propagation of Perennial Weeds."

Professor Pammel, whose work on the seedcoats of Leguminosæ and Euphorbia is well known, issues as contribution No. 6 from the Botanical Department of the Iowa State College a paper on the seeds and testa of some Cruciferæ, reprinted from the *American Monthly Microscopical Journal.* The paper is freely illustrated by figures showing the macroscopic appearance and microscopic structure of the seeds studied.

Dr. F. Höck, Oberlehrer in Luckenwalde, has recently published a concise elementary treatise on botanical geography.[1]

Under the title "A First Ohio Weed Manual,"[2] Professor A. D. Selby publishes an instructive discussion of the weed question in general and a descriptive illustrated list of Ohio weeds.

Lathyrus splendens, a beautiful species of Southern California, is figured in the *Gardeners' Magazine* for February 12.

Vanilla is considered with respect to its botany, cultivation, microscopy and chemistry in the *Journal of Pharmacy of New York* for February.

The principal weeping willows form the subject of an instructive article by A. Rehder in *Moeller's Deutsche Gärtner-Zeitung* for February 19, in which good figures are published of *Salix elegantissima*, *S. alba vitellina pendula*, *S. blanda*, and *S. salomoni.*

[1] Höck, F. *Grundzüge der Pflanzengeographie.* Unter Rücksichtnahme auf den Unterricht an höheren Lehranstalten. Breslau, Ferdinand Hirt, 1897. 190 pp., 50 ills., 2 maps.

[2] Ohio Agricultural Experiment Station, *Bulletin No. 83.* Wooster, Ohio, September, 1897. 8vo, 249–400 pp., 71 ills.

The rupestris section of Selaginella, as represented in the United States, forms the subject of a paper by Professor Underwood in the *Bulletin of the Torrey Botanical Club* for March, in which six species and one variety are described as new, and two previously described forms are resurrected as of specific rank.

Prof. E. A. Burt publishes in the *Botanical Gazette* for March a useful paper on collecting and preparing fleshy fungi for the herbarium.

In the fourth Heft of the current volume of Engler's *Botanische Jahrbücher*, Professor Engler brings to a conclusion his series of "Beiträge zur Flora von Africa." The contributors to this concluding paper are Engler, Hoffmann, and Kränzlin.

Professor Spegazzini, in the *Revista* of the La Plata agricultural and veterinary Faculty for August and September last, publishes an annotated list of something over two hundred species of Patagonian plants, several of which are described as new, under the title "Primitiæ floræ Chubutensis."

A novel local flora is the *Flora urbica pavese*, published by Traverso in the *Nuovo Giornale Botanico Italiano* for January, and enumerating an even century of flowering plants and ferns which grow spontaneously in the city of Pavia.

The third *Bulletin of the New York Botanical Garden* contains an interesting series of reports on the organization and administration of the establishment, a surprisingly long list of plants cultivated in 1897, and descriptions and illustrations of the proposed plant houses and museum building. The sites of the garden and the proposed zoological park are indicated on a simple outline map of Bronx Park.

Under the title of *The Cactus Journal*, a new monthly, devoted exclusively to cacti and other succulent plants, largely from the point of view of the cultivation of such plants, has been started in London. The first number, for February, 1898, is illustrated by two well-executed gelatine prints, from photographs, illustrating a number of interesting cacti.

From a study of the paper of a Hebrew document from the synagogue of Old Cairo, Mr. Dawson concludes that as far back as the year 1038, — the date assigned to the manuscript, — the process of manufacturing paper from the fibers of the flax plant was both known and employed.[1]

[1] *Annals of Botany*, **12**: 111–115, March, 1898.

GEOLOGY.

A New Edition of Dana's Geology. — Dana's *Revised Text-Book of Geology*[1] has recently appeared in a dress that is much more attractive than that so familiar in earlier editions. Professor Dana had begun a revision of the work a short time before his death. The completion of the revision has been undertaken by Prof. W. N. Rice, of Wesleyan, and with great success. The distinctive characteristics of earlier editions have been retained in the new edition, but the volume has been modernized by the replacement of the old zoological and botanical classifications by those adopted in recent manuals, by a fuller recognition of the theory of evolution as a working hypothesis in paleontology, and by a modification of earlier statements concerning metamorphism. The ending *yte* for rock names has also been abandoned for the more usual *ite*.

In his preface to the new edition the editor declares that he undertook the revision with the understanding that the book "was to be brought down to the present time as regards its facts, but it was still to express the well-known opinions of its author." That he was the right man for the delicate task of "editing" this, the most popular of Dana's works, is abundantly proven by the excellence of the new book. It still presents all of its author's well-known views on debatable questions, and yet is, in the main, a splendid compendium of the truths of geology as now accepted by conservative students of the science.

In one or two points only can ultra conservatism be charged. The Archean remains undivided, no distinction having been made between the typical clastic pre-Cambrian rocks and the series of crystalline schists that lie unconformably beneath these, — a distinction that is now made by nearly every geologist who has worked in undoubted pre-Cambrian regions.

With respect to the treatment of the topic metamorphism the same fault may be found. The editor leaves the impression on the reader's mind that nearly all the gneisses, mica-schists, etc., are recrystallized sedimentary rocks, though, it is true, he declares that in some cases they may be produced from plutonic rocks. He also suggests that granite itself may be of metamorphic origin, in spite of the fact that no specialist in the study of rocks has ever

[1] Dana, James D. *Revised Text-Book of Geology.* Fifth edition. Revised and enlarged. Edited by William North Rice. American Book Company, 1897. ix + 482 pp., 464 ills.

discovered any evidence that this is the case. Unfortunately the distinction between bedding and schistosity is not made clear. The secondary structure, by inference at any rate, is made coincident with the primary one, for we read that "the presence of a schistose structure is not always proof of origin from sediments."

Of course Professor Rice had a very difficult position to fill. He has filled it well, and yet we wish for the sake of the students who will use the revised text-book that he had departed a trifle more from Professor Dana's views, and incorporated in the book the latest results of investigations upon the oldest rocks of the globe and on metamorphism.

W. S. B.

MINERALOGY.

The Fourth Edition of Fuchs's Determinative Mineralogy.[1]—Although the *Anleitung zum Bestimmen der Mineralien*, by Prof. Dr. C. W. C. Fuchs, was first published thirty years ago, and has since been revised by Professors Streng and Brauns, the well-known volume still preserves its original excellent features. The third edition was published only eight years ago. Since this time there has been so much added to our knowledge of minerals that a fourth edition has been demanded. Dr. Brauns, who is responsible for the new edition, is eminently fitted for the work that has devolved upon him, and the new volume that has been brought out under his direction is fully abreast of the times.

There has been little change made in the sections treating of blowpipe and microchemical reactions except such as are necessitated by the progress of knowledge during the past decade. The tables for the determination of minerals, however, have been entirely reconstructed. The minerals are no longer separated into groups according to their crystal systems, but are divided according to hardness. These groups are further divided into two classes, *viz.*, minerals with metallic luster and those without metallic luster. The metallic minerals are next subdivided according to color, and the non-metallic ones according to the color of their streak. The cleavage, crystal form, and manner of occurrence serve further as distinguishing characteristics, and simple chemical tests are made use of for pur-

[1] Fuchs, C. W. C. *Anleitung zum Bestimmen der Mineralien.* Vierte Auflage, neu bearbeitet, von Dr. Reinhard Brauns. Giessen, J. Ricker, 1898. xii + 235 pp.

poses of final identification. As far as possible only those chemical reactions are described that are necessary to identify the minerals, and these are always simple ones.

The book is too well known to all mineralogists to require further characterization. It is sufficient praise to state that the fourth edition is an advance over all the editions that have preceded it.

W. S. B.

Hardness of Minerals. — Jaggar has described[1] a new instrument for the determination of the hardness of minerals. After briefly summarizing the results of previous workers on this subject, he describes the chief sources of error in their methods as follows: "(1) personal variability due to using 'visibility' of a scratch as determinant; (2) inequalities of surface; (3) undefined details of instrument. To eliminate (1) the depth of abrasion should be definite and measurable; to eliminate (2) the surface should be artificial and defined, and the boring method, where only a very small portion of the surface is initially touched, should be used; to eliminate (3) every part of the instrument, including the abrader, should be minutely defined, and for comparative determination an empirical standard should be fixed."

The instrument devised to overcome these difficulties and to meet the other conditions of the problem presented is intended to be applied to the microscope in order that the measurements may be made either on a crystal face or the surface of a thin section, that the test may be applied to very small portions of mineral, and that the control of the instrument may be very exact. "The principle of the instrument is as follows: a diamond point of known, constant dimensions is rotated on an oriented mineral surface, under uniform rate of rotation and uniform weight, to a uniform depth. The number of rotations of the point, a measure of the duration of the abrasion, varies as the resistance of the mineral to abrasion by diamond; this is the property measured. The instrument consists of the following parts:

(1) A standard and apparatus for adjusting to microscope with various adjustments.

(2) A balance beam and its yoke.

(3) A rotary diamond in the end of the beam.

(4) Apparatus for rotating uniformly.

[1] Jaggar, T. A., Jr. A Microsclerometer for Determining the Hardness of Minerals. *Am. Jour. of Sci.*, vol. iv, pp. 400–412, 1897.

Also *Zeit. f. Krystall.*, vol. xxix, pp. 262–275, 1898.

(5) Apparatus for recording rotations.
(6) Apparatus for locking and releasing beam.
(7) Apparatus for recording depth.

After giving detailed descriptions of the various parts of the instrument and the method of use and calibration, the results are given of a preliminary series of tests on the minerals of the Mohs scale of hardness, and the following table shows the values obtained, together with those of two other investigators for comparison:

	PFAFF, 1884.	ROSIWAL, 1892.	JAGGAR, 1897.
9. Corundum	1000	1000	1000
8. Topaz	459	138	152
7. Quartz	254	149	40
6. Orthoclase	191	28.7	25
5. Apatite	53.5	6.20	1.23
4. Fluorite	37.3	4.70	.75
3. Calcite	15.3	2.68	.26
2. Gypsum	12.03	.34	.04

The possibility is suggested of using the instrument for other ends than the determination of hardness; the extreme exactness of the appliance for measuring the vertical movement of the diamond point makes it possible to determine the thickness of a mineral section, and of the thickness of a mineral necessary to produce in polarized light a given interference color, whence the double refraction may be calculated. The borings from very minute crystals in thin section might also be subjected to chemical tests, — a novel method of isolation.

Tables of Crystal Angles. — Goldschmidt, continuing his valuable work on the use of the goniometer with two circles, has published a table[1] of angles for the forms of all crystallized minerals. The construction of such a table is first made possible by the new method of measurement of crystals involved in this goniometer. In the old method of measurement of interfacial angles, such a table involved the presentation of the angles which each form makes with every other, and the number of values would be so great that its very bulk would render it impracticable or even useless. Monographs on individual mineral species contain approximations to such complete tables of angles, but these were widely scattered through the literature. But with the two-circle goniometer, each face is determined independently, once the crystal is oriented on the instrument, by the measurement of two angles which suffice, the crystallographic ele-

[1] Goldschmidt, V. *Krystallographische Winkeltabellen*. Berlin, J. Springer, 1897.

ments being known, for the complete characterization of the form. Thus the table of angles is vastly simplified, and reference to it for any newly measured form is easy.

The present table contains, besides these two characteristic angles, ϕ and ρ, for each form, several supplementary angles which facilitate the comparison of measurements made by the two methods, and also several linear values of use in plotting the gnomonic projection of the forms.

An introduction contains necessary explanations of the values given in the tables and the schemes employed for each system for calculating the various values from the elements and symbol of the form. The total number of values tabulated is something over 70,000, of which nearly one-half required separate calculation, the remainder being such fixed values as 60 or 45 degrees. A summary of the number of minerals crystallizing in each system and of their forms is interesting. There are in

Isometric	System,	102	minerals	with	719	simple	forms.
Tetragonal	"	47	"	"	589	"	"
Hexagonal	"	91	"	"	1457	"	"
Orthorhombic	"	170	"	"	2783	"	"
Monoclinic	"	122	"	"	2157	"	"
Triclinic	"	21	"	"	404	"	"
Total		553	"	"	8109	"	"

The publication of these tables removes one of the frequently urged objections to Goldschmidt's instrument and method of calculation, — that it had no connection with the great mass of observations hitherto made and gave results which could not be directly used and compared with those of other observers. The contrary is now true, for this work brings together in simple form an enormous mass of results previously not nearly so accessible. It is a logical conclusion to the elegant system of crystal measurement and discussion which the author has developed and should do much to extend the use of his time and labor-saving methods among students of crystallography.

Catalogue of Minerals. — Chester[1] has published a new edition, revised to date, of his list of minerals. It gives all the names in common use, stating of each whether it be a species or variety name, or a synonym. The approximate chemical composition is given after each species. The list serves as a convenient check-list, its alphabetical arrangement increasing its usefulness in this way.

[1] Chester, A. H. *A Catalogue of Minerals.* New York, J. Wiley & Sons, 1897.

SCIENTIFIC NEWS.

THIS is the jubilee year of Professor W. K. Brooks, and it seemed, therefore, to his pupils, past and present, an appropriate time to make some especial demonstration of the affection and esteem in which he is held by all of them, who include many of the leading zoologists of this country. Accordingly a committee, consisting of Professors H. H. Donaldson, W. H. Howell, E. A. Andrews, E. B. Wilson, H. V. Wilson, S. Watasé, and T. H. Morgan, was appointed and arrangements were made to present him with a portrait. His birthday, March 25, was the date chosen for the presentation, which was made by Professor Howell in the presence of twenty-two of the subscribers assembled at Brightside, Professor Brooks's home near Baltimore. The portrait, which was painted by Mr. Thomas C. Corner, is a very good likeness and represents Dr. Brooks seated with an open book in an attitude that is very characteristic and will call to mind many an interesting hour in the little "seminary room" of the Biological Laboratory at Johns Hopkins.

The Reception Committee of the Fourth International Congress of Zoology has issued a circular containing particulars with regard to lodgings and other accommodation at Cambridge during the meeting in August next, and giving other information as to the railway fares from various parts of the Continent, and other arrangements for the Congress. The circular is accompanied by a reply-form, to be filled out and returned to the Secretaries by any member of the Congress who wishes rooms to be taken for him. These circulars have been sent to all who have already informed the Reception Committee that they hope to be present at the meeting, and will be sent to other zoologists who apply to the Secretaries of the Reception Committee, The Museums, Cambridge, England.

At the meeting of the Council of the Boston Society of Natural History, April 20, it was unanimously voted to award the Grand Honorary Walker Prize of $1000 to Mr. Samuel Hubbard Scudder, of Cambridge, for his contributions to entomology, fossil and recent. The Walker prizes in natural history were established in 1864 and, in addition to the annual awards for memoirs on subjects proposed by a committee, provide for a Grand Honorary Prize to be given

not oftener than once in five years. The provisions of Dr. Walker's foundation allow the Council to pay "the sum of $500 for such scientific investigation or discovery in natural history as they may think deserving thereof, provided such investigation or discovery shall have first been made known and published in the United States of America, and shall have been at the time of said award made known and published at least one year; if, in consequence of the extraordinary merit of any such investigation or discovery, the Council of the Society shall see fit, they may award therefor the sum of $1000." The Grand Honorary Walker Prize was first awarded in 1873 to Dr. Alexander Agassiz for his investigations in the embryology, geographical distribution, and natural history of the echinoderms. Since this first award in 1873, the Grand Honorary Walker Prize has been given to Professors Joseph Leidy, James Hall, and James D. Dana. In all cases the maximum amount, $1000, has been given.

Papers read at the April meeting, 1898, of the National Academy of Sciences: The Coral Reefs of Fiji, A. Agassiz. The Fiji Bololo, A. Agassiz and W. McM. Woodworth. The Acalephs of Fiji, A. Agassiz and A. G. Mayer. The Variation in Virulence of the Colon Bacillus, J. S. Billings. Biographical Memoir of Edward D. Cope, Theodore Gill. New Classification of Nautiloidea, Alpheus Hyatt. A New Spectroscope, A. A. Michelson. On the Hydrolysis of Acid Amides, Ira Remsen and E. E. Reid. The Question of the Existence of Active Oxygen, Ira Remsen and W. A. Jones. On the Product formed by the Action of Benzenesulphonchloride on Urea, Ira Remsen and J. W. Lawson. On Double Halides containing Organic Bases, Ira Remsen. McCrady's Gymnophthalmata of Charleston Harbor, W. K. Brooks. Ballistic Galvanometry with a Counter-twisted Torsion System, Carl Barus. A Consideration of the Conditions governing Apparatus for Astronomical Photography, Charles S. Hastings. The Use of Graphic Methods in Questions of Disputed Authorship, with an Application to the Shakespeare-Bacon Controversy, T. C. Mendenhall. A Method for obtaining a Photographic Record of Absorption Spectra, A. W. Wright. Theories of Latitude Variation, H. J. Benedict, introduced by A. Hall. Progress in the New Theory of the Moon's Motion, E. W. Brown, introduced by S. Newcomb. On the Variation of Latitude and the Aberration-Constant, Charles L. Doolittle, introduced by S. S. Chandler. A Curious Inversion in the Wave Mechanism of the Electromagnetic Theory of Light, Carl Barus.

The first of what promises to be a helpful series of guides in nature study has recently been issued by Mr. G. W. Carver, of the Normal and Industrial Institute at Tuskegee, Alabama, and, although it consists of only twelve small pages and costs but five cents, it is full of suggestions useful alike to teacher and pupil.

The concluding numbers of vol. vii of the *Journal of Comparative Neurology* (March, 1898) contain the editorial announcement that with the next volume the efficiency of the journal will be greatly increased by the addition of a number of new collaborators, among whom are Dr. Adolf Meyer, Dr. B. F. Kingsbury, Prof. G. C. Huber, and Prof. Ludwig Edinger. The present numbers include, beside the usual literary notices, an article by the chief editor on Psychological Corollaries of Modern Neurological Discoveries, Inquiries Regarding Current Tendencies in Neurological Nomenclature, by C. L. and C. J. Herrick, and a lengthy contribution on the Motor Nerve-Endings and on the Nerve-Endings in the Muscle-Spindles, by G. C. Huber and L. M. A. De Witt.

The Psychological Index, No. 4, published under the auspices of *The Psychological Review*, contains a bibliography of the Literature of Psychology and Cognate Subjects for 1897. The 2465 titles are arranged in convenient subdivisions under eight general divisions, and the list is concluded with an excellent authors' index. The Index aims at completeness, for which it begs the coöperation of authors and publishers.

The city of Geneva, Switzerland, has received the estate of Sécheron and 300,000 francs by the will of Philippe Plantamour, and will probably convert the estate into a botanic garden, thus supplementing the present garden behind the university.

The bill passed by the legislature of Maryland appropriating $50,000 for two years for the Johns Hopkins University has but two faults. It appropriates too little, and the appropriation is made for too short a time. There is nothing which has proved such a credit to the state of Maryland as this university, and its present serious financial condition is due to the depreciation of securities which it bought from the state.

Cornell University will maintain a summer school of botany this year from July 5 to August 15.

Professor A. E. Verrill, of Yale, has gone to the Bermudas with a party of students.

The Ornithological Union of Vienna has disappeared as a distinct organization, and now forms a section of the Royal-Imperial Zoological-Botanical Society. The quarterly journal of the union, *Die Schwalbe*, is discontinued after twenty-four volumes.

The Museum of Natural History of Paris has recently acquired the Ragonot collection of Microlepidoptera and the Berthelin collection of fossil Foraminifera.

We learn from *Natural Science* that a natural history museum is being established in the Vatican, geological and mineralogical collections being already displayed.

Bradney B. Griffin, a fellow of Columbia University, died in New York, March 26, aged 26. He was a promising zoologist, and had published articles upon the invertebrate fauna of Puget Sound and upon the fertilization of Thalassema. A larger paper on this same subject was in the printer's hands at the time of his death.

The United States National Museum has received a second specimen of the fish *Acrotus willoughbyi*, of the family Stromateidæ. Like the type and only known specimen, it comes from Washington, and will probably supplement the information derived from the former incomplete specimen. The type was described as having the bones of the head so weak that a pull of about five pounds would pull off the head. This second specimen is stated to have the head mutilated.

Mrs. Phœbe Hearst has given a building for the School of Mines to the University of California. The building will be fully equipped at her expense.

The Belgian Academy of Science offers prizes of $120 for the best articles upon the following subjects: Digestion in Carnivorous Plants; Development of a Platode, and its bearings upon the question of the relations of Platodes to Enterocœles; Do the Schizophytes possess a nucleus? and if so, what is its nature and how does it divide? The competition is open to all.

Jules Marcou died in Cambridge, Mass., April 17. He was born in Salins, department of the Jura, April 20, 1824, studied geology, and in 1847 was appointed to the paleontological staff of the Sorbonne. In 1848 he came to the United States, where he worked in connection with Agassiz. 1851 and 1852 he spent in Europe, and in 1855 he received the appointment of professor of geology in the University of Zürich. In 1860 he returned again to the United

States, which became his home until his death, although he made several longer or shorter visits to Europe. He published several books and many shorter papers upon the geology of the United States.

Sir William Turner, professor of anatomy in the University of Edinburg, has been elected corresponding member of the Academy of Sciences of Berlin.

Lawrence Bruner, state entomologist, and professor of entomology in the University of Nebraska, has returned from his year spent in the Argentine Republic, where he has been studying the locust plague.

The University of Nebraska will maintain a summer school this summer, offering eighteen courses, among them botany, zoology, entomology, and geology. The session will extend from June 6 to July 16.

Mr. E. H. Lonsdale died March 7 at Columbia, Mo. From an obituary sketch by Dr. C. R. Keyes in the *American Geologist*, we learn that Mr. Lonsdale was born in 1868, educated at the University of Missouri. He was connected at two different times with the geological survey of his native state and with the geological survey of Iowa. At the time of his death he was a member of the staff of the United States Geological Survey. He published several papers of the Geology of Missouri and Iowa, and at the time of his death was at work at a large report on the clays of the latter state.

The University of Chicago has made the following appointments to fellowships: Anthropology, A. W. Dunn; Geology, C. E. Siebenthal, W. N. Logan, J. W. Finch, R. George; Zoology, H. H. Newmann, H. E. Davis, R. S. Lillie, M. F. Guyer, Emily R. Gregory; Neurology, I. Hardsty; Archæology, Caroline L. Ransom; Botany, W. R. Smith.

Prof. David S. Kellicott, of the University of Ohio, died at his home in Columbus, April 13, aged about 48 years. For several years he was engaged in teaching Natural History in the State Normal School at Buffalo, N.Y., and while there he held various offices in the Buffalo Society of Natural Science. In 1888 he was called to the chair of zoology in the Ohio State University as successor to Albert H. Tuttle. His work was largely in the lines of the Protozoa, fresh-water sponges, and the Odonata, of which he described many new forms. He had been elected General Secretary of the American Association for the Advancement of Science to serve at the fiftieth anniversary meeting this year in Boston.

Prof. W. Pfeffer, of Leipzig, delivered the Croonian Lecture before the Royal Society, March 17, upon the nature and significance of functional metabolism in the plant.

The legislature of Massachusetts has granted $200,000 this year to aid in the hopeless task of trying to exterminate the gypsy moth.

Recent appointments: Dr. Charles R. Barnes, of the University of Wisconsin, professor of vegetable physiology in the University of Chicago. — Dr. W. B. Benham, of the University of Oxford, goes to the University of Otago, Dunedin, New Zealand, as successor to the late Professor Parker. — A. L. Bolk, professor of anatomy in the University of Amsterdam. — G. Born, professor of anatomy in the University of Breslau. — G. C. Bourne, lecturer on comparative anatomy in the University of Oxford. — Prof. Carl Chun, of Breslau, professor of zoology in the University of Leipzig, as successor to Leuckart. — H. T. Fernald, professor of zoology in State College, Pennsylvania, economic zoologist of Pennsylvania. — B. E. Fernow, chief of the Division of Forestry in the United States Department of Agriculture, director of the school of forestry in Cornell University. — Baron von Firks, assistant in geology in the mining school at Freiburg, Saxony. — Dr. Sigmund Fuchs, professor extraordinarius of physiology in the University of Vienna. — Henry Hanna, demonstrator of biology, geology, and paleontology in the Royal School of Science, Dublin. — Harold Heath, assistant professor of zoology in Leland Stanford University. — Dr. P. Malera, professor of physiological chemistry in the University of Naples. — Prof. F. Morini, professor of botany at Bologna. — H. W. Pearson, assistant curator of the herbarium of the University of Cambridge. — Cornelius L. Shear, of the University of Nebraska, assistant agrostologist in the United States Department of Agriculture. — H. W. M. Tims, professor of zoology in Bedford College, Bedford, England. — Dr. Warburg, professor of botany in the University of Berlin.

Recent deaths: N. Alboff, Russian botanist, at La Plata. — Dr. Delmas, geologist, at Custries, France. — Rev. William Houghton, ichthyologist, at Wellington, England. — Professor Kirk, of New Zealand, author of important works on the flora and forestry in the colony. — Alfred Monod, cryptogamic botanist, aged 61. — F. W. Seydler, botanist, at Braunsberg, aged 80. — James Thompson, student of Coleoptera. — Dr. T. C. Winkler, curator of the Teyler museum at Haarlem, well known as a student of fossil vertebrates.

CORRESPONDENCE.

BIRDS OF THE GALAPAGOS ARCHIPELAGO.[1]

Editor *American Naturalist.*

Sir: — The September number of the *American Naturalist* contains a criticism of my "Birds of the Galapagos Archipelago" which I have not answered sooner from want of time. I would gladly pass it by were it not that certain erroneous quotations and important misconstructions contained in Dr. Baur's "criticism" should not be allowed to stand uncorrected.

Regarding a certain missing box of specimens from the southern part of Albemarle Island, Charles Island, etc., Dr. Baur says: "I shall now make a few remarks about the birds from Charles, Hood, Barrington, and South Albemarle, which were contained in a box which disappeared in Guayaquil. The loss is not quite so unfortunate as stated by Mr. Ridgway. He remarks that it contained more than forty land birds from the southern part of Albemarle Island, but this statement, as will be seen from the list which I now give, is not correct."

In a letter (now in my possession) dated Oct. 12, 1891, Dr. Baur wrote me: "That *Creagrus* is a very common bird you probably have heard already from Mr. Adams; also, that we got *over forty species of birds from S. Albemarle.*" In another dated March 1, 1892, he wrote: "One box containing other *small birds* has unfortunately been lost on the way, probably at Panama, and so far no trace of it has been found"; while in still another, dated April 29, 1894, he says: "It is a great loss that one box with small birds was stolen at Guayaquil. I see now that it contained the specimens from Charles, Hood, Barrington, and South Albemarle."

Since Dr. Baur distinctly wrote me, as quoted above, that he and Mr. Adams collected more than forty species of birds on South Albemarle, and later twice informed me they were *small* birds, it will be seen that I was justified, from the knowledge in my posses-

[1] With Mr. Ridgway's kind consent, his letter written Nov. 19, 1897, has been withheld from publication on account of the unfortunate illness of Dr. Baur, which prevented us from submitting the letter to him for comment or reply. Dr. Baur, being in Europe at present, is still ignorant of this letter, but it does not seem wise or fair to Mr. Ridgway to delay its publication any longer. — EDITOR.

sion at the time, in the statement which I made concerning the box in question.

With further reference to the birds of South Albemarle, Dr. Baur makes the following singular statement: "Ridgway enumerates thirty-five species from Albemarle, and remarks: 'As Dr. Baur and his associate, Mr. Adams, collected more than forty species in South Albemarle, there are at least twenty-five species found there which are as yet undetermined.' I cannot support this statement. Ridgway himself names thirty-three species collected by us." Concerning this I have only to say that reference to pages 469 and 470 of my paper will show that it is wholly unwarranted. The list of thirty-five species, thirty-three of them collected by Baur and Adams, given by me on page 469, is plainly not a list of birds of *South* Albemarle but of Albemarle Island *as a whole.* On page 470 of my paper are separate lists for "East Albemarle, opposite Cowley Island" and "South Albemarle," both copied from lists furnished me by Dr. Baur, the originals of which I still possess. The South Albemarle birds, as enumerated by Dr. Baur, number sixteen species. Having no reason to doubt Dr. Baur's statement that he and Mr. Adams "got over forty species of birds from S. Albemarle," and since "over forty species" would necessarily be equivalent to at least forty-one, and since sixteen subtracted from forty-one would leave "at least twenty-five species" to be accounted for, it would appear that my statement was strictly in accordance with the facts as known to me. Dr. Baur has named nine of the species which were unknown to me; therefore, there should be still "at least" sixteen unidentified species of South Albemarle birds. Not one of these nine additional species was included in the two lists of Albemarle birds which Dr. Baur sent me, nor were they contained in the collection which he sent for my examination. There is good reason, therefore, why they were omitted from my list.

It is difficult to understand why Dr. Baur should have criticised my remarks concerning the large white heron from Albemarle, given in my paper as doubtfully *Herodias egretta*, but which Dr. Baur is positive is that species. The doubts which I expressed as to the bird being that species were based upon Dr. Baur's description of its size ("as large as, perhaps larger than, *A. herodias*"), which certainly cannot apply to *H. egretta*. The latter is conspicuously *smaller* than *A. herodias* (only about one-third its bulk[1]). There-

[1] Audubon gives the weight of *H. egretta* as two and a half pounds; *A. herodias* often weighs as much as seven pounds.

fore, it necessarily follows that either Dr. Baur's statement of the size of the bird which he saw but did not obtain is very incorrect, or else that my doubt as to its being *H. egretta* was very well founded. It would be interesting to know by what process Dr. Baur was able, under the circumstances, to positively identify the species.

In the "Additions to the List of Birds given by Ridgway for the Different Islands" (pages 782–84), I have found it difficult to find out exactly what Dr. Baur means to show; but in my attempt to do so have made one important discovery, which is that the species named, which are really additional to the lists given in my paper for the separate islands, were certainly not among the specimens which Dr. Baur sent me for examination, and therefore I cannot be responsible for the omissions. Many of the species which he names do occur in my lists, however, but in the case of most of these, *owing to the circumstance that no Baur-Adams specimens were known to me*, the "x" was not entered in the column for that collection. The importance of the portion of the collection which was not sent to me may be realized from the fact that, according to Dr. Baur's paper, his collection contained specimens of *Camarhynchus pallidus* ("*Cactornis pallida*") from Duncan, Chatham, and Jervis Islands, while he sent me only two specimens, one from Jervis, the other from James Island. Neither did I see a specimen of *Nesomimus macdonaldi* from Gardner Island; had I been able to do so, it is hardly necessary for me to say that the mistake respecting the identification of this bird to which Dr. Baur refers (see footnote on page 783) would not have occurred.

The remaining point upon which Dr. Baur's criticisms bear is the first one mentioned by him, and the one to which he devotes most space; but I prefer to consider it last and most briefly, since it is chiefly a matter of opinion, while the others are questions of fact. What are genera and what are not is, in many cases, very difficult to determine. To Dr. Baur *Cactornis* and *Geospiza* seem to be distinct, and to have them so would better fit his theory of distribution. To me they are not distinct, because it is impossible to draw any line between them.[1] It is, of course, disappointing to find sometimes that facts do not entirely support our theories; but it seems to me

[1] I would here call attention to Dr. Baur's erroneous quotation of my remarks on page 778, where, in the eighth line from the bottom, the following should be inserted after the first word: "I am still of the opinion that not a single character can be found."

both unscientific and unsafe to draw artificial lines of demarcation in such cases, even when Nature's neglect to do so causes serious inconvenience.

ROBERT RIDGWAY.

SMITHSONIAN INSTITUTION, WASHINGTON, D. C.,
November 19, 1897.

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THE FRESH-WATER BIOLOGICAL STATIONS OF AMERICA.

CHARLES A. KOFOID.

THE fundamental purpose of all biological stations, both marine and fresh-water, is essentially the same. They serve to bring the student and the investigator into closer connection with nature, with living things in their native environment. They facilitate observation and multiply opportunities for inspiring contact with, and study of, the living world. They encourage in this day of microtome morphology the existence and development of the old natural history or, in modern terms, œcology, in the scheme of biological education.

The predominance of the marine station is but natural, for American biology was cradled at Nahant and Penikese. Until recently, practically all the great centers of biological investigation and instruction have been located almost within sound of the sea. It was also to be expected that the seaside laboratory would attract the inland biologist who is searching for a place in which the summer can be passed with both pleasure and profit, and that the abundance and novelty of the marine fauna would overshadow if not entirely eliminate all attention to the fresh-water fauna of the vicinity, attractive though it might be.

This supremacy of interest in marine biology is not, however, confined to the seaside laboratory; it finds its way into textbooks and schoolrooms. Laboratory guides in which marine types very largely predominate are not unknown, and too many a teacher of biology in collegiate courses and in the secondary schools of our inland towns depends upon marine forms for laboratory study and demonstration, to the sad neglect of the fauna with which both he and his pupils come in daily contact. From a pedagogical point of view this element of remoteness in the objects of study is unfortunate, for it tends to abridge the sympathetic contact with nature and the development on the part of the pupil of a lively interest in the world of life about him, a feature of large cultural value in all biological education.

The writer has found a widespread feeling in biological circles that the fresh-water environment affords far less of value for investigation and instruction than the marine. Considered merely volumetrically, the marine fauna may well have the advantage, but all the general problems of biology can be approached with ease, and at times to even greater advantage at the fresh-water station; and, furthermore, in variety and richness the fauna of fresh water, in some localities at least, compares very favorably with that at the seaside. It may then be that one of the functions of the fresh-water station is to preserve and foster an interest in fresh-water life and to emphasize its availability and utility for purposes of instruction. In no sense of the word, however, are the marine and fresh-water stations to be regarded as rivals; each is the necessary complement of the other, and both alike have their place in the field of biology.

The movement which has resulted in the establishment of a number of fresh-water biological stations in the north central states in the past few years has had a variety of sources. Prominent among these have been, doubtless, the successful examples of the marine stations, and the desire on the part of inland workers to have near-at-hand resorts for summer work which should offer to their students analogous advantages without the expense attendant upon a trip to the seashore. The

existence in some of the states in question of natural history surveys under the patronage of the state has in a few instances been the means of furnishing the funds for the conduct of these enterprises. The fundamental reason, however, for the biological station movement is neither a mere local demand nor an opportune opening, but a deep-seated purpose on the part of the men who stand as sponsors for the stations, to extend biological exploration, to increase the facilities for, and raise the standard of, biological instruction in their respective states, and finally and principally to contribute in some substantial way to the solution of some of the fundamental problems of biology, as, for example, the problem of variation, or the œcology of a river system.

Aside from the three stations noticed at length in this article, whose past history and material equipment entitle them to recognition as permanent institutions, there have been other enterprises which have done the work of a biological station, though not formally organized as such. The fortunate situation of the University of Wisconsin upon the shores of Lake Mendota, rendering unnecessary the establishment of an independent outpost, has made it possible for Professor Birge to carry on for several years past a series of connected observations upon the Crustacea of the plankton. The results of this work — a credit to any biological station — have been published by the Wisconsin Academy of Sciences.[1] The work of exploration in this state will be continued elsewhere during the present summer under the auspices of the State Survey.

The Michigan Fish Commission for several years carried on a biological examination of many of the smaller lakes of the state. Professor Reighard, of the University of Michigan, was in charge of the work, and in 1893 made a more thorough and systematic survey of Lake St. Clair. In 1894 a biological examination of the northern end of Lake Michigan was made by a party in charge of Dr. H. B. Ward. The results of these explorations have appeared from time to time in the Bulletin of the Commission. The work upon the Great Lakes will be resumed this summer under the auspices of the United States

[1] See review in this journal, No. 376, pp. 282–284.

Fish Commission by a party in charge of Professor Reighard, located at Put-in-Bay, in Lake Erie.

The University of Minnesota maintained for several years at Gull Lake a laboratory for summer work in connection with the Natural History Survey of that state. The establishment of a station has also been agitated in the state of Iowa during the past year. The University of Rochester is raising funds for the equipment of a station at Hemlock Lake, thirty miles south of Rochester, in western New York. This station will probably be opened next year, and will occupy buildings furnished by the city of Rochester. Instruction will be the main purpose of its organization.

The description of the Ohio station, given herewith, was one of the last pieces of work which its late director, Prof. D. S. Kellicott, accomplished before his fatal illness. The account of the Indiana station was furnished by its director, Prof. Carl Eigenmann.

THE LAKE LABORATORY OF THE OHIO STATE UNIVERSITY.

This laboratory is at Sandusky, on the grounds of the city's pumping station, near a cove of the East Bay. It consists of the second story of the State Fish Hatchery; there is one large room with work table, and three small ones for the use of investigators. The supply of trawls, plankton nets, seines, insect nets, etc., is ample. Microscopes, reagents, and glassware are supplied as needed from the university. There is also a small sailboat. The most pressing needs, by way of equipment, are better aquaria and a larger and more seaworthy boat; these will be added in the future.

Sandusky is as favorable a place for the study of fresh-water fauna and flora as is likely to be found on the Great Lakes. Many species of fish spawn in the bays or about the adjacent islands; crustaceans, worms, sponges, and protozoans are abundant. If one wants a most favorable place to study water birds, none is better in this latitude than the extensive marshes and sand dunes in the vicinity of Sandusky.

The purpose of the station is simply to afford a convenient plant for students and instructors of the State University first, and any one else when there is room, to study the living forms of this favorable locality.

Work has been carried on at Sandusky for two summers. Some of the lines of work undertaken, in which progress has been made, are these: (*a*) fishes inhabiting the bays, their food and parasites; (*b*) nesting habits of the marsh-inhabiting birds; (*c*) the aquatic insects; (*d*) the Rotifera; (*e*) the fresh-water sponges; (*f*) the crayfishes. Some progress has been made in determining the amount, character, and distribution of the plankton.

The collections are mostly transferred to the university, and abstracts of the work reported to the Ohio Academy of Science, usually as reports of progress on the biological survey, which is being directed by a committee of the academy. The station will be open but a short time in 1898, as the survey is to be carried on in other parts of the state.

This station is in no sense a school; every man looks after his own interests, giving and receiving advice, as occasion may demand.

The Biological Station of Indiana University.

A biological station for the Indiana University was suggested by Professor Eigenmann to the Board of Trustees in 1893, and he was enabled to open the station in 1895. The object in view being well defined and a number of localities being from a natural standpoint equally suitable, the location was determined by the finding of an old boathouse suited to the purpose on the shores of Turkey Lake. Windows were cut, boards laid to cover the larger cracks in the floor, and work begun.

As there was no fund available to defray the expenses of the station, a number of courses of instruction were offered to raise the necessary money, to permit a few "laboratory grubs" to attain their full development, and to start a few other students at work in the natural habitat of the beginner in zoölogy — the woods, the water, and the fields.

During that year a map was made of the lake bottom, a brief survey of the animal contents was undertaken, and material was collected for the main object of the station, the study of variation.

The trustees appropriated in the two years following $200 and $300, respectively, to provide permanent equipment to carry on the work and furnish accommodations for additional students.

INDIANA BIOLOGICAL STATION

A building 18 × 55 feet, two stories high, was erected for the station by the owner of the ground.

The conditions for biological work, coupled with camp life on a fine lake, five miles from the nearest village, free from the university lecture-hour appointments, proved so attractive that during the second summer the number of students rose from 19 to 32, and in the third to 68.

The advantages for biological work at a biological station all recognize to be ideal; here some of the enthusiasm of the older natural history is aroused. To the special advantages mentioned should be added the acquisition on the part of the student of the ability to help himself, to adapt himself to new environments. Most of the failures by teachers of biology in the secondary

as well as higher schools have come from their inability to work with the means found at hand, and their inability to adapt themselves to a new environment.

The object of the station can best be expressed in the words of the first announcement.

RESEARCH. — The main object of the station will be the study of variation. For this purpose a small lake will present a limited, well-circumscribed locality, within which the differences of environmental influences will be reduced to a minimum. The study will consist in the determination of the extent of variation in the non-migratory vertebrates, the kind of variation, whether continuous or discontinuous, the quantitative variation, and the direction of variation. In this way it is hoped to survey a base line which can be utilized in studying the variation of the same species throughout their distribution. This study should be carried on for a series of years, or at least be repeated at definite intervals to determine the annual or periodic variation from the mean. A comparison of this variation in the same animals in other similarly limited and well-circumscribed areas, and the correlation of the variation of a number of species in these areas will demonstrate the influence of the changed environment, and will be a simple, inexpensive substitute for much expensive experimental work.

For this work the situation of Lake Wawasee, surrounded as it is by other lakes, some of them belonging to other river basins, will be admirably adapted.

In connection with this study of the developed forms the variation in the development itself will receive attention ; for instance, the variation in segmentation, the frequency of such variation, and the relation of such variation in the development to the variation in the adult, and the mechanical causes affecting variation.

INSTRUCTION. — Courses of instruction which ordinarily cannot be given in the university's laboratories during the college year will be offered, and credit given on the university's records. The courses are as follows :

1. *Elementary work.* The class will collect, preserve, and study a series of animals occurring in the neighborhood of the station. Emphasis will be laid on the nature of the fresh-water fauna, and the correlation and adaptation of organisms. The entire day will be given to collecting excursions, laboratory work, and lectures, with individual work on Saturdays. No special preparation is needed. (Teachers may collect material for their classes, but alcohol for this purpose will not be furnished.) 2. *Embryology* and life history of fishes and other local forms. 3. *Special investigations* in the variation of non-migratory vertebrates and survey of the physical and biological conditions of Lake Wawasee.

During the second and third years maps of a number of northern lakes have been prepared. A general survey of the Turkey Lake fauna has been published. A very large amount of material has been collected to illustrate the annual variation, the birth-mean, and the effect of selective destruction. Two papers on variation have been published, but most of the material is still to be examined.

As to the future, the Winona Assembly has offered to erect two buildings, each 20 × 57 feet and two stories high, on the shores of Eagle or Winona Lake, Indiana, eighteen miles from our present location. This lake had been decided upon for the location of the station in the first instance, but was given up because no suitable building was available. The trustees of the university have agreed to appropriate $1000 for the permanent equipment of these buildings. They will be ready for occupancy in 1899. Aside from laboratories for bacteriology, physiology, embryology, zoölogy, and botany, there will be about a dozen small rooms for the instructors and for visiting naturalists who care to make use of the facilities offered. Courses of instruction will be offered in the subjects mentioned. The study of variation will be continued and other problems will be added, one of which will be the rearing of cave animals in the light.

ILLINOIS BIOLOGICAL STATION.

For a number of years the investigation of the aquatic life of the lakes and streams of Illinois has been prosecuted under the auspices of the State Laboratory of Natural History, in connection with the Natural History Survey now in progress in the state, under the direction of Prof. S. A. Forbes. From time to time parties equipped for biological exploration have been sent out, and have occupied temporary posts of observation on the Mississippi River or elsewhere. No permanent station was established, however, until April, 1894, when, with the joint support of the State Laboratory of Natural History and the University of Illinois, a station was opened upon the Illinois River at Havana. For the equipment of this work $1800 was

appropriated. For the two years beginning July 1, 1895, this joint support was continued, $2500 being appropriated by the legislature for equipment, and $3000 per year for running expenses. In 1897 the appropriation for running expenses of the station was renewed, but the whole amount was given

ILLINOIS BIOLOGICAL STATION.

through the State Laboratory of Natural History, and the name of the station was changed from "The Biological Experiment Station of the University of Illinois" to "Illinois Biological Station."

From its beginning the station has enjoyed the deep interest and wise guidance of its experienced director, Prof. S. A. Forbes. Until July 1, 1895, the station was in the immediate charge of Prof. Frank Smith; since that date the conduct of its operations has been in the hands of the present superintendent.

The equipment of the station consists of a house boat or floating laboratory, 20 × 60 feet over all, well lighted and ventilated, containing a private laboratory and office, a main laboratory, a storeroom, and a kitchen. In the center of the larger laboratory stands a long sink for aquaria, supplied with water from an overhead tank. The tables in the laboratories will provide working accommodations for twenty persons. A steam launch, licensed to carry seventeen passengers, furnishes a convenient means of transit to and from the various collecting grounds, and a half-dozen rowboats add to the facilities for field operations. The station is supplied with nets and seines of various kinds for the collection of fishes and other aquatic vertebrates, with a collecting lantern and nets for field work in entomology, with a large number of breeding cages for the rearing of aquatic larvæ of insects, with dredges, sieves, dip nets, and Birge nets for bottom and shore examinations, and with tow nets, plankton nets, pumps, centrifuges, and counting machines for the qualitative and quantitative investigation of the plankton. The laboratory is also supplied with a number of aquaria, a liberal allowance of glassware and reagents, and in its more extended summer operations is further furnished from the biological laboratories of the university.

The library of the State Laboratory of Natural History is exceptionally complete in the literature of fresh-water fauna and flora, and is available for the use of the biological station. The leading monographs and many of the scattered papers dealing with the Protozoa, Rotifera, Oligochæta, Entomostraca, and aquatic insects are provided. Systematic and faunistic work upon these groups is further facilitated by the large number of collections in the possession of the state laboratory from the waters of the state and many other parts of the continent. Among the collections is a series of named European Entomostraca sent by eminent specialists (Sars, Schmeil, Lilljeborg, and Poppe); these are of great value in unraveling the synonymy of this group, and in establishing the validity of American species or their identity with European forms. They also afford a basis for the study of comparative variation in the two continents.

The field of operation of the station is, for the present at least, the Illinois River and its related waters. Geologists tell us that this stream and its bottom lands occupy the bed of an ancient river, a former outlet of Lake Michigan. The present flood plain is but slightly above the level of the river, and overflows are, therefore, of more than usual extent and frequency. The fall of the stream is very slight, about thirty feet in two hundred and twenty-five miles, and at times of flood the area covered is over seven hundred square miles. Over fifty-six square miles in the field of the station's operations are submerged at high water, and of these seventeen represent the river, lakes, bayous, and permanent marshes of low-water stages. The extreme fluctuation in the river level recorded at Havana is eighteen feet, and a rise to sixteen feet above low water is not unusual in the spring or early summer. Owing to dams, the river at low water is practically a series of slack-water pools. The river thus presents a considerable change in conditions during the year. Although at high water it is practically a unit in environment, as the water recedes a number of distinct and characteristic aquatic areas emerge, and are quickly differentiated by their peculiar fauna and flora. At low water there thus lies within easy reach of the station a wide range of situations, including the river and its tributary streams, Spoon and Quiver Rivers, a shallow ephemeral lake quite free from vegetation, a large impounding lake and bayou without tributaries, several spring-fed lakes with different amounts of vegetation, and a number of marshes of varying degrees of permanence. This extremely varied environment, and the considerable and sometimes sudden fluctuations in the water level, add greatly to the complexity of the biological problems with which our station has to deal.

The fertility of the drainage basin of the river, the large amount of sewage emptying into the stream, and the rich alluvial soil of the bottom lands favor the growth of aquatic vegetation. At low water a rank growth of Ceratophyllum fairly chokes many of the lakes, and at times even encroaches upon the river. Nelumbium and Nymphæa, Lemna, Wolffia, and Azolla abound, and water-blooms of Euglena, Carteria,

Anabæna, and Clathrocystis are of frequent occurrence. The plankton is remarkable alike for the large number of individuals and of species it contains, while in volume per cubic meter it, at times, exceeds almost all published records. The fauna, as well as the flora, is conspicuous for its abundance and variety. Although no efforts have been made to accumulate complete faunal lists, over one hundred species of Protozoa have been recorded, as well as a like number of Rotifera. Spoon River has long been noted for the abundance, variety, and size of its Unionidæ, thirty species of which are known to occur in the vicinity of Havana; there are in addition forty-five other species of aquatic Mollusca, largely univalves. Through the efforts of Professor Smith over thirty species of Oligochæta have been found, including a number of new and interesting forms. Aquatic insects abound, over three hundred and fifty species being known to occur in the vicinity. An interesting feature of the richness of the fauna is the occurrence of certain zoölogical rarities whose range, as hitherto known in this continent at least, has been limited; as, for example, Urnatella and Lophopus among the Bryozoa, and Trochosphæra among the Rotifera.

The essential objects and general methods of the Illinois station are best expressed by its director, Professor Forbes, in his last biennial report.

> It is the general, comprehensive object of our biological station to study the forms of life, both animal and vegetable, in all of their stages, of a great river system, as represented in carefully selected typical localities. This study must include their distinguishing characters, their classification and variations, their local and general distribution and abundance, their behavior, characteristics, and life histories, their mutual relationships and interactions as living associates, and the interactions likewise between them and the inanimate forms of matter and of energy in the midst of which they live. We are, in short, to do what is possible to us to unravel and to elucidate in general and in detail the system of aquatic life in a considerable district of interior North America.
>
> So vast a subject must of course be intelligently divided and studied part by part, in some systematic order, to avoid a dissipation of effort and to insure the speedy attainment of some definite and tangible results. Its most obvious divisions are the systematic, the biographical, and the œcological;

and this is the order, broadly speaking, in which the general investigation must be carried on. Both systematic and biographical biology have a high independent value in our scheme, but both are with us chiefly means to the remoter end of a study of the interactions of associate aquatic organisms, and of their relations to nature at large. It is thus the œcological idea which is to lead in the organization and development of our work. A systematic survey of the biological assemblage is a necessary preliminary step, and the tracing of life histories and the recognition and description of immature stages is a scarcely less essential prerequisite; for without the knowledge which these studies are to give us, it would be obviously impossible to make any comprehensive study of variations, distribution, and œcological relationships.

The œcology of the Illinois River is greatly complicated, and the difficulty of its study intensified, by certain highly and irregularly variable elements of the environment. Apart from those secular and more or less inconstant features of climate and weather which must be taken into account wherever such studies are prosecuted, we often have here the evidently very large and highly intricate reactions produced by periodic variations in the river level, and the consequent enormous extensions and corresponding diminutions of the mass of the waters and of the area covered by them. Fortunately for the possibilities of success in so difficult a field, progress in it does not require that the entire system of life should be studied as a unit at first. Special problems may be selected, of a kind to be brought easily within the available time and the capacities of the individual investigator, which, being worked out one by one, may be later brought together as contributions to a solution of the larger problems involved.

In actual practice it has been found that our work may best be opened up by comprehensive studies of the classification, such as will give us a critical knowledge of all the forms occurring in our field, and access to the published literature of each; and by parallel or slightly subsequent studies of their habits, life histories, and local distribution and abundance.

The principal methods of the biological station are those of field and laboratory observation and record, collection, preservation, qualitative and quantitative determination, description, illustration, generalization, experiment, induction, and report.

By close and persevering observation in the field, we learn much of the actions, habits, and haunts of animals, of the special conditions under which they live, and of many similar matters which cannot possibly be learned in any other way; and not a little of this knowledge is necessary to an intelligent treatment of both general and special problems in biology.

The acute, persevering, sympathetic observer of living nature — the "old-fashioned naturalist," in short — is best to be understood as a "synthetic

type," all of whose best qualities should be not only preserved but intensified among his variously differentiated progeny. It is the biological station, wisely and liberally managed, which is to restore to us what was best in the naturalist of the old school united to what is best in the laboratory student of the new.

As our work progresses and special problems are taken up for separate and continuous investigation, the experimental method will necessarily come prominently into use. The object of biological experimentation is the interpretation of nature, and, like all intelligent experimental work, it must be suggested and guided by observation and hypothesis. With us it is the œcological field in which experiment is especially called for. Given certain phenomena of local distribution, of relative abundance, of association, of habit, of variation, and the like, whose causes it is desirable to ascertain, it is incumbent upon us, by a critical and exhaustive study of the environment to find the materials for rational hypotheses as to such causes, and to test such hypotheses by experimental procedure. It is thus always the field observation, or the laboratory observation made under conditions which involve the least practicable departure from natural conditions actually existing, which must precede and suggest the experiment. The method and the general object of this work resemble thus more closely, on the whole, those of the agricultural experiment station— which is, indeed, a biological station under another name and devoted to a special end— than those of the laboratory of experimental physiology; and it is because ours is to be in the end and in its final objects a station for the solution, by experimental methods, of both special and general problems in the field of œcology that it was christened by its official board of control the Biological *Experiment* Station of the University.

As the work of the station is still in its earlier stages, the papers thus far published give the results of the preliminary explorations, and, consequently, are of a systematic, faunistic, or biographical character in the main. A report upon the aquatic Hymenoptera and a considerable portion of the Diptera and Lepidoptera, by Mr. C. A. Hart, has already been published, and additional papers upon the Odonata and Ephemeridæ are in preparation. It is the purpose of these papers to elucidate the life histories of the insects of these groups by giving a detailed account of the identified eggs, larvæ, and pupæ, together with a discussion of their seasonal and local distribution, their habitat, food, etc. As a result of the breeding work carried on at the station, immature stages, hitherto undescribed, of two hundred and twenty-five species have been obtained.

The investigation of the Oligochæta has been carried on for several years; thirty species are known to occur. Two new genera and at least seven new species have been found. Three papers have appeared upon the subject, and a final report is in preparation by Professor Smith. The results of the examination of the Turbellaria of the station have been published by Dr. W. McWoodworth, seven species being found, of which two are new. Some new species of Rotifera and Protozoa have been described by Mr. A. Hempel, and a report upon the local and seasonal distribution of these groups has been completed. Three papers upon the Entomostraca, prepared as zoölogical theses by students in the university, have been based in part upon station collections. A report upon the Ostracoda of North America, by R. W. Sharpe, a revision of the North American species of the genus Diaptomus, by F. W. Schacht, and a paper upon the North American species of Cyclopidæ, by E. B. Forbes, have appeared, and a fourth paper upon the remaining genera of the Centropagidæ is ready for the press.

The plankton work of the station has resulted in the accumulation of a large number of collections and a mass of data upon the local and seasonal distribution of pelagic organisms. Considerable attention has been given to the sources of error in the plankton method, and efforts have been made to secure a reliable and convenient basis for the quantitative and statistical study of the aquatic world.

Although the station was established primarily for purposes of investigation, its relation to biological education has not been neglected. As soon as permanent quarters were occupied, the facilities of the station were thrown open to students and teachers, twenty of whom availed themselves of the privilege in 1896. No formal instruction was given, each person following his own inclination as to the line of work undertaken, with such incidental guidance and assistance as the station staff could afford. A summer school with definite courses, especially for teachers, was planned for 1897, but, owing to the temporary loss of funds for the maintenance of the station, the project was abandoned. For the summer of 1898 an offer is made of elementary and advanced courses in both botany and zoölogy.

These courses will be supplementary to regular university work, and will, to some extent, be especially adapted to the needs of teachers of biology in the secondary schools. Tables at the station will also be reserved for the use of visiting investigators and students of special subjects.

For the successful accomplishment of the fresh-water work certain desiderata are evident: more precise and reliable methods for the quantitative and statistical study, not only of the plankton, but also of shore and bottom forms; more biographical work, studies of life histories in the broadest sense of the term, including precise observations upon the environment and its relation to the life cycle; more models of experimental work that shall make clear the feasibility of the application of the methods of the physiological laboratory to the study of the factors of environment; more biological stations, so that the conclusions arrived at in one locality may be extended and corrected in a score of others; and, finally, some biological Frœbel, who shall demonstrate the disciplinary and cultural value of œcology as a field of biological instruction and establish a standard for others to imitate.

The future of the fresh-water biological stations is bright with the hope of accomplishment, but their problems lie not wholly along the beaten paths of the past. In their work we may look for the happy combination of the sympathetic observation of the old-time naturalist, the technical skill and searching logic of the morphologist, and the patient zeal and ingenuity of the experimental physiologist, a combination, let us hope, that shall unlock not a few of the secrets of the world of life.

ON THE IDENTIFICATION OF FISH ARTIFICIALLY HATCHED.

HERMON C. BUMPUS.

ALTHOUGH the United States Fish Commission has annually hatched and planted many millions of young fish, and although the planting has often resulted in the apparent increase in the number of adults where the plantings have been made, there is nothing but circumstantial evidence to show that the fish appearing in increased numbers are really the adults of the young artificially produced. The recent excessive abundance of cod along the shores of New England is probably the result of extensive operations at the Woods Holl hatchery. The facts that these fish were small when they first appeared, that they have since increased in size, that they have occurred in localities where cod had never before been caught, and that they are reported to be of a different color from the native variety are interesting, although to the sceptical they are not absolutely convincing. There is need of some scheme whereby the adults of fish hatched artificially may be distinguished from those native to the locality.

To mark the fry is, of course, out of the question, but is it not possible that the fry mark themselves, *i.e.*, is there not a slight difference between the fish of the same species but of different localities, and if there is this slight difference, does it not present itself in a measurable manner?

The careful examination of a large number of periwinkle shells[1] (*Littorina littorea*) has shown that localities even near together are characterized by shells of different proportions. This fact has warranted the examination of a number of fish for the purpose of seeing if they too are not subject to similar varietal changes.

During the latter part of March of the present year, while

[1] *Zoölogical Bulletin*, vol. i, No. 5, February, 1898, p. 247.

at the Laboratory of the United States Fish Commission, I examined several hundred winter flatfish (*Pleuronectes americanus*) with the following results:

Of 100 flatfish collected at Woods Holl, only one had 62 dorsal fin-rays, seven had 63, twelve had 64, twenty-two had

59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74

FIG. 1.

65, etc., as represented by the ordinates of curve *A* in Fig. 1. The amplitude of variation is between 62 and 72, the arithmetical mean being 66, represented by the vertical line at the right of 66.1, curve *A*. The curve drawn through the upper ends of the ordinates represents graphically the distribution of the 100 variants around this mean.

If we now tabulate the dorsal fin-rays of an equal number of flatfish from another locality, it is evident that if the fishes in both localities are alike, the curves will coincide. If they are different, even slightly so, the lack of coincidence will indicate the difference. The curve drawn at *B*, Fig. 1, is based on the enumeration of the dorsal fin-rays of 100 flatfish taken at Waquoit, Mass., from a small bay only eight miles east from Woods Holl. Compared with curve *A*, the Waquoit curve lies further to the left, has a longer base, and a less altitude. The Waquoit collection thus contains several fish, the number of dorsal fin-rays of which are less in number than those of fish taken at Woods Holl. The Waquoit fish are more variable, the amplitude at Woods Holl being from 62 to 72 (eleven points), while the amplitude at Waquoit is from 60 to 71 (twelve points). The depressed curve of distribution in the second curve is an indication of greater variability and general indifference to the "ideal mean." The arithmetical mean, represented by the vertical line, is 65.2, the Waquoit fishes averaging about one dorsal fin-ray less than the Woods Holl specimens.

Curve *C* represents the distribution of 100 flatfish from Bristol, R. I., from a body of water located about fifty miles west of Woods Holl. Compared with curve *A*, the Bristol curve lies further to the left and has a broader base, though its culminating point is very definitely indicated. The arithmetical mean is 64.9.

It is thus seen that there is a measurable difference between collections of fish from different localities, even though the fish *individually* present no perceptible difference.

There is correlated with the increase or decrease in the number of dorsal fin-rays, an increase and decrease in the number of anal fin-rays, as shown in Fig. 2. The Woods Holl specimens average a large number of dorsal and also a large number of anal fin-rays, 66.1 dorsals and 49.7 anals. The Waquoit specimens average a less number of dorsal fin-rays (65.2), and they also have a less number of anal fin-rays (48.6). The Bristol specimens average only 64.9 dorsal fin-rays and 48.7 anal fin-rays. The individuals also partake of this corre-

lation, those having a larger number of dorsal fin-rays tending towards the possession of a larger number of anal fin-rays.

If it is proposed to test the result of re-stocking a locality in which a species of fish has become reduced in numbers, it is necessary to first determine the "curve of distribution" from

41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56

Fig. 2.

fish native to the locality, and this curve may be based on any measurable structural character, such as the number of fin-rays, the number of scale-rows, or the number of vertebræ. One must then determine the "curve of distribution," for the same structural character, of fishes of the same species, but abundantly found at another locality, from which the "brood fish"

are to be taken. After the "planted fish" have had time to mature, new curves should be plotted for the first locality. If these curves are practically the same as those originally made, it is reasonable to conclude that the re-stocking has been ineffectual. If, however, the new curve approaches the curve of the locality from which the "brood fish" were taken, it is reasonable to conclude that the influence of the foreign specimens has been felt, and the re-stocking has been effectual.

The following objections may be raised to the above method:

(1) It may be that, due to the small number of specimens (100), the curve *A* is not characteristic of the Woods Holl specimens, and its difference from curve *B* is only accidental. To test this source of possible error I have examined three separate groups of flatfish, all from the same locality, each group containing 100 specimens. The resulting curves are strikingly alike. Of course it would be much more satisfactory to base all the curves on the enumeration of the fin-rays of one thousand rather than one hundred specimens, but even one hundred specimens yield fairly definite results, though the curves are somewhat uneven.

(2) It may be that the variation in the position of the curves is a result of age, *i.e.*, the fishes from Woods Holl averaged a larger number of fin-rays because they were somewhat older.

If there is an increase in the number of fin-rays on the part of the older specimens, this increase can be readily detected by simply comparing the average number of fin-rays of the younger with the average number of fin-rays of the older fish. Fifty-three young fishes, less than 10 inches in length, have a mathematical average of 66.1 dorsal fin-rays. Forty-seven older fishes from the same locality, all over 10 inches in length, average practically the same number of fin-rays, *i.e.*, 66.3. In this collection of 100 fishes, the fourteen smallest have a greater average number of fin-rays than the fourteen largest. There is then no material increase in the number of fin-rays with increase in age.

(3) It may be that the variations tabulated in Fig. 1 are the result of environmental conditions expressed upon the fry and young — acquired characters of questionable hereditary value;

i.e., it may be that the fry reared at Woods Holl would attain to a larger number of dorsal fin-rays than the *same* fry reared at Waquoit.

While certain experiments that the writer has made induce him to believe that these variations in the number of dorsal fin-rays may be deep-seated blastogenic characters, the influence of the environment, even if it should affect the ontogenic process, cannot vitiate the method, for if it is insisted that certain external influences may affect the fry *after* liberation from the hatchery, and the results of these influences are expressed by a change in the fin-ray formula, it must also be equally true that the more extreme and unusual environmental conditions imposed upon the still younger organism while *within* the hatchery, will leave their stamp also, and the artificially hatched fish will thus present some peculiarity, acquired though it may be, which will be brought out by the plotting of "curves of distribution."

THE WINGS OF INSECTS.

J. H. COMSTOCK AND J. G. NEEDHAM.

CHAPTER III (*Continued*).

IX. THE VENATION OF THE WINGS OF HYMENOPTERA.

The Hymenoptera belong to the series of orders in which the direction of specialization of the wings results in a reduction in the number of the wing-veins. This is true of the wing as a whole, the reduction taking place in the anal area of the wing as well as in the pre-anal area. We have found no representative of the order in which all of the veins have been preserved ; and in the more specialized forms nearly all of the veins have disappeared.

A study of all of the families of the order shows that the most generalized of living forms, so far, at least, as concerns the structure of the wings, are to be found in the families Siricidæ and Tenthredinidæ. In these we find a close approximation in the number of wing-veins to the hypothetical type. But even here the courses of the branches of the forked veins have been greatly modified. These changes have been so great that the determination of the homologies of the wing-veins in this order was one of the most difficult problems of the kind that arose in the course of the study of the wings of insects.

This determination was made by the senior writer from an examination of the wings of adults before our present method of ontogenetic study was devised.[1] In the course of the present investigation we have endeavored to test the accuracy of his conclusions by a study of the tracheation of the wings of hymenopterous pupæ. We have found, however, that although the wings of the more generalized forms are abundantly supplied with tracheæ, the courses of these tracheæ have not been modified in the same way as have the courses of the veins with which they correspond. For this reason we are still forced to

[1] Comstock, *Manual for the Study of Insects*, pp. 603–607.

determine the homologies of the wing-veins by a comparative study of the wings of adults. We will, therefore, point out first what we believe to be the method of specialization of the

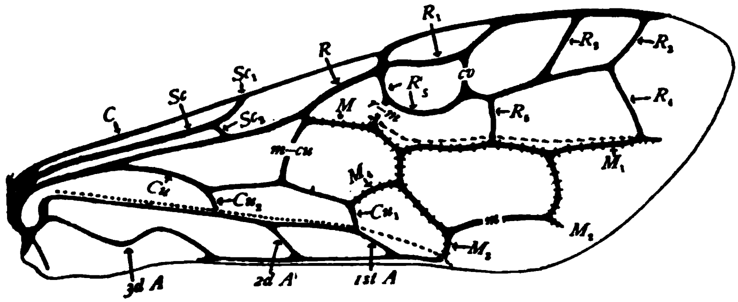

FIG. 38. — The veins of a typical hymenopterous wing.

wing-veins that has taken place in this order; and later we will discuss the nature of the changes that have taken place in the arrangement of the tracheæ.

The method of specialization of wing-veins which has taken place in the Hymenoptera can be most easily seen by a study of the fore wings of certain sawflies. The most useful for this purpose that we have found belong to the genera Pamphilius and Macroxyela. If we are right in our interpretation of the wings of these insects, there is preserved in each genus all of the primitive wing-veins with a single exception. And,

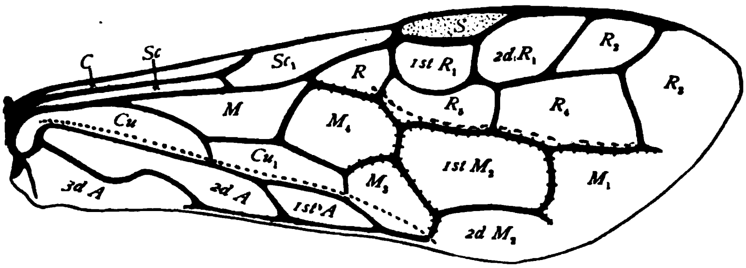

FIG. 39. — The cells of a typical hymenopterous wing.

as in each of these genera a different vein is lost, we are able to make a figure of a typical wing from a study of the two genera. Figs. 38 and 39 represent such a wing; in the former the veins are lettered; in the latter, the cells.[1]

[1] Figs. 38 and 39 represent the venation of the fore wing of Pamphilius, except that vein R_2, which is lacking in this genus, is added. This vein is well preserved

In the wings of these sawflies the anal furrow and the median furrow are both well marked, and are in the typical positions; that is, the anal furrow is immediately in front of the first anal vein, and the median furrow in front of the media. The furrows are represented by dotted lines in the figures.

In the anal area the three typical veins are preserved; but they coalesce to a considerable extent, both at the base and near the margin of the wing.

In the basal part of the pre-anal area the stems of the principal veins are as follows: the costa coincides with the costal margin of the wing (Fig. 38, *C*); the subcosta (*Sc*) is well preserved and is forked; back of the subcosta is a strong stem formed by the coalescence of the other three veins; the cubitus (*Cu*) soon separates from this stem, extending in a curve towards the anal furrow; while the radius and the media coalesce for about half their length. In order to make these veins more distinct in the figure we have marked the free portion of the media with cross lines.

When we pass from the consideration of the main stems to a study of the branches, we meet a much more complicated problem, a problem which could not have been solved by a study of Hymenoptera alone. But a knowledge of the methods of specialization of the wings of Diptera gives a key to an understanding of the wings of Hymenoptera.

In the preceding article of this series we pointed out that in many Diptera there is a marked tendency for veins to coalesce from the margin of the wing towards the base. In the Hymenoptera this tendency is much more marked and has been carried to a much greater extent, resulting in a very complicated arrangement of wing-veins, even in the most generalized members of the order.

If the reader will examine the series of figures illustrating the coalescence of veins Cu_2 and *1st A* in the Diptera,[1] he will find it easy to understand what has taken place in the Hymenoptera. In the Hymenoptera, however, both branches of the

in Macroxyela but in Macroxyela vein Cu_2 is lost. See Comstock, *Manual for the Study of Insects*, p. 606, for figures of the wings of these two genera.

[1] *American Naturalist*, vol. xxxii, No. 377, pp. 338, 339.

cubitus coalesce with the first anal vein; and this coalescence has proceeded so far that both branches cross the anal furrow and end in the anal vein remote from the margin of the wing.

It should be noted that vein Cu_2 is rarely preserved in this order, even in the more generalized forms. We have found it

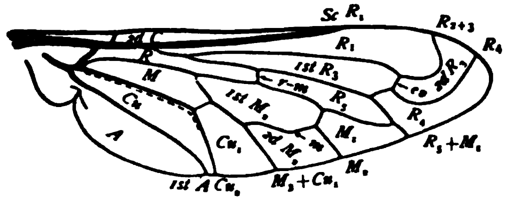

FIG. 40. — Wing of Pantarbes.

only in the genus Pamphilius. In Macroxyela[1] the position of the fork of the cubitus is indicated by a bend in this vein.

If the branches of the media be now examined, it will be seen that vein M_1 (Fig. 38) extends longitudinally near the center of the distal part of the wing, its primitive course being modified slightly if at all. Vein M_2 follows a course similar to the course of this vein in the dipterous genus Pantarbes (Fig. 40); so also does the medial cross-vein (Fig. 38, *m*). A comparison of the position of cells M_1, *1st* M_2, and *2d* M_2 in these two genera (Figs. 39 and 40) is very instructive.

Returning to Pamphilius (Fig. 38), we see that vein M_3 coalesces with the first anal vein, crossing the anal furrow near

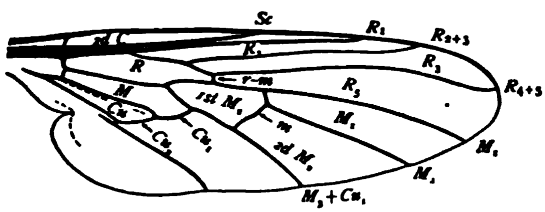

FIG. 41. — Wing of Rhamphomyia.

the margin of the wing. It is evident that the forces that are causing the branches of the cubitus to migrate along the first anal vein and towards the base of the wing are exerting a similar influence on this vein. It is also evident that vein M_4 and Cu_1

[1] Comstock, *loc. cit.*, Fig. 735.

coalesce at the tip, and that the migration of the united tips of these veins (marked Cu_1 in the figure) towards the base of the wing has so modified the course of that part of vein M_4 which is still free that this part of this vein extends towards the base of the wing. This change is very similar to the change in the course of vein Cu_2 in the dipterous genus Rhamphomyia (Fig. 41).[1]

A curious result of this change in the direction of the course of vein M_4 is that the cell M_4 has been closed and pressed back to the center of the wing (Fig. 39, M_4), and now lies in front of the free portion of vein M_4 instead of behind it. A somewhat similar modification of cell M_3 has been pointed out

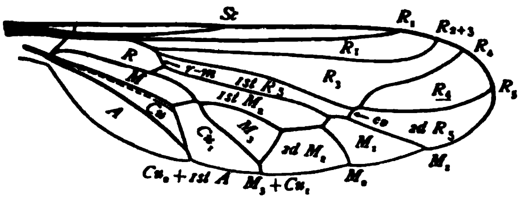

FIG. 42. — Wing of Eulonchus.

in the Diptera; we repeat the figure of the wing of Eulonchus for comparison (Fig. 42).

Let us now consider the courses of the branches of the radius. Here again we can gain help from a study of dipterous wings. Observe in Pantarbes (Fig. 40) the coalescence of the tips of veins R_5 and M_1. In the Hymenoptera a similar coalescence of veins R_5 and M_1 has occurred; but it has proceeded much farther, so that the free portion of vein R_5 in Pamphilius (Fig. 38, R_5) is remote from the end of the wing and has the appearance of a cross-vein.

In the Hymenoptera vein R_5 has been followed in its migration along vein M_1 by vein R_4, which has now reached a stage in Pamphilius that is quite similar to that reached by vein R_5 in Pantarbes. But like vein R_5 it has the appearance of a

[1] At the time that the figures in Comstock's *Manual* were prepared it was believed that the media was typically three-branched. For that reason the vein which we now regard as vein M_4 was believed to be a cross-vein. The interpretation given above accords better with what we have since learned to be the typical form of the media.

cross-vein. In the fore wing of the honey-bee (Fig. 43) veins R_4 and R_5 still retain the appearance of branches of a forked longitudinal vein.

In Pamphilius vein R_1 is curved away from the costal margin of the wing to make room for a stigma (Fig. 39, *S*), and vein R_3 ends in the costal margin a short distance before the apex of the wing (Fig. 38). Vein R_2 has been lost in this genus, but is well preserved in certain closely allied forms,[1] and is, therefore, represented in the figure.

While the tips of the branches of the radial sector have migrated away from the apex of the wing, the bases of these

FIG. 43. — Wings of Apis.

branches coalesce in the opposite direction; from these two causes results the transverse bracing of the radial area of the wing, which is a very characteristic feature of the venation of the wings in this order.

The details of these changes will be made clear by an examination of Figs. 44 and 45. The former represents the primitive mode of branching of the radius; the latter, the radial area of the typical hymenopterous wing (Fig. 38). In the hymenopterous type veins R_{2+3} and R_{4+5} of the primitive type coalesce so far that the branches of the sector arise from a common stem; and the tips of all of them have moved away from the apex of the wing, veins R_2 and R_3 following the costal margin of the wing; and veins R_4 and R_5 following

[1] See p. 414, footnote.

vein M_1. In the Hymenoptera a cross-vein has been developed between veins R_1 and R_s. But this is not a peculiarity of this order; a similar cross-vein exists in many insects, and has been represented in our figures of the wings of a nymph of Nemoura.[1]

From the foregoing account it will be seen that even in the most generalized of living Hymenoptera there exists a highly

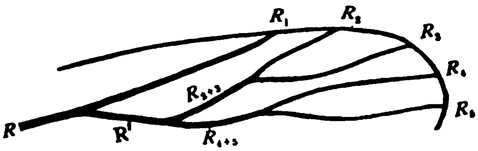

FIG. 44. — The typical radius.

modified wing venation. The indication of the details of the further modifications exhibited by the more specialized members of this order has already been done by one of us in another place. We will, therefore, merely refer to a single illustration.

When the fore wing of a honey-bee (Fig. 43) is examined it is found that, although this insect exhibits a wonderfully high development of instinctive powers, it retains a comparatively generalized wing venation. This wing, however, is much more modified than the fore wing of Pamphilius; and hence a comparison of the two is instructive.

In the honey-bee the subcosta is lost; so, too, is the second branch of the radius. Veins R_4 and R_5 retain a more general-

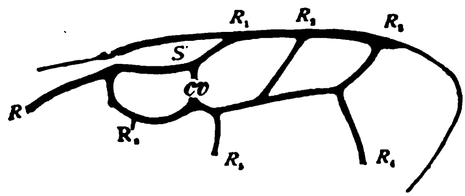

FIG. 45. — The radius in Hymenoptera.

ized condition than do these veins in the sawflies. The coalescence of the radius and the media extends farther than in Pamphilius, the base of the free portion of the media being carried farther from the base of the wing than the medio-cubital cross-vein (*m-cu*). This results in the base of the free

[1] *American Naturalist*, vol. xxxii, January, 1898, pp. 46, 47.

portion of the media (M) being V-shaped. No trace of the second branch of the cubitus remains; and vein Cu_1 appears as a short cross-vein, extending to the anal furrow near the middle of its course. But the most striking modification of all is exhibited by vein M_4; the tip of this vein in its migration towards the base of the wing has passed over an arc of nearly 180°, so that now it extends from the point where it separates from vein M_3 directly towards the base of the wing, and joins the medio-cubital cross-vein.

X. The Tracheation of the Wings of Hymenoptera.

In our studies of the wings of the more generalized insects we found a close correlation between the venation and the tracheation of the wings. It can be accepted as a firmly established fact that the courses of the wing-veins of primitive insects were determined by the courses of preëxisting tracheæ. And one of the principal objects of the present investigation was to endeavor to settle certain questions regarding the homologies of wing-veins by a study of the tracheæ that precede these veins.

The importance of this method of study has been well shown by the results which we have obtained. But we also found that in the Trichoptera[1] there is little correlation between the venation and the tracheation of the wings, a remarkable reduction of the wing-tracheæ having taken place. A similar reduction of the tracheæ of the wings exists in most families of Diptera; and even when a large proportion of the tracheæ are retained, as in certain Asilids, they afford little aid in the determining of the homologies of the wing-veins. For this reason we omitted a discussion of the tracheation of the wings of Diptera. Again, in the Hymenoptera we find that the courses of the tracheæ cannot be depended upon for determining the homologies of the wing-veins. But here, in the more generalized members of the order, we find a very complete system of wing-tracheæ; and it is, therefore, incumbent on us either to point out the correspondence between the tracheæ

[1] *American Naturalist*, vol. xxxii, April, 1898, p. 256.

and the wing-veins, or to demonstrate that such a correspondence does not exist.

In the introductory article of this series,[1] in discussing the figures of the wings of a nymph of Nemoura, we called attention to the fact that the tracheæ in the wings of that insect extend in straight lines or in gentle curves, while in some cases the corresponding veins are much more angular; and we offered the following explanation of this phenomenon:

> It is evident from this that in the perfecting of a wing as an organ of flight the position of a vein in the adult may become quite different from that of the corresponding trachea of the immature form. In other words, although there is no doubt that the courses of the principal wing-veins of

FIG. 46 — Wings of a pupa of Tremex.

> primitive insects were determined by the position of the principal tracheæ of the wings, the wing-veins have been more or less modified to meet the needs of adult life; while at the same time the tracheæ of the immature wing, serving the purpose of respiration, and lying more or less free within the wing-sac, have not been forced to follow closely the changes in the cuticular thickenings of that sac.

In the Hymenoptera, as we have shown, the courses of the branches of the forked veins, in those forms where they have been preserved, have been so modified that these branches extend more or less transversely, making sharp angles with the main stems. It is not strange, therefore, that the tracheæ of the wings of the pupa lying free within the wing-sac, have not followed these changes.

[1] *American Naturalist*, vol. xxxii, January, 1898, p. 47.

Fig. 46 represents the wings of a pupa of Tremex; and Fig. 47, the fore wing of a pupa of Apis. In both cases the main tracheæ extend in nearly direct lines from the base of the wing to near its outer margin. This fact alone would indicate that the needs of respiration of the pupa, rather than the flight function of the adult wing, has been the important factor in determining the courses of these tracheæ.

A comparison of the fore wing of Tremex with that of Apis shows a remarkable difference in tracheation. In Tremex vein R_s is traversed by a branch of the radial trachea (R); while in Apis the radial trachea is not branched, and the trachea traversing vein R_s arises from the cubital trachea (Cu).

When this fact was first observed it was thought that the

FIG. 47. — Fore wing of a pupa of Apis.

trachea of the radial sector in Apis had become transferred from the radial trachea to the cubital. We were not greatly surprised at this phenomenon, for a similar switching of tracheæ is common in those Lepidoptera in which the branches of the media become joined to the adjacent veins.

It was found, however, that this is not the explanation of the change. An examination of the wings of young pupæ of the honey-bee revealed the fact that in this insect the laying out of the wing venation precedes the tracheation of the wing. After the wing-veins reach that stage of development in which they appear as pale bands, the tracheæ grow out from the base of the wing into them. Fig. 48 represents the wings of a pupa taken at a stage which illustrates this pushing out of the tracheæ into the previously formed wing-veins.

It is obvious that tracheæ developed in this way will follow the paths offering the least resistance to their progress; and

that it is not to be expected that the tracheæ will preserve their primitive arrangement under these conditions. This brings us to the conclusion, already announced, that in determining the homologies of the wing-veins in the Hymenoptera we are forced to base our conclusions on a study of the veins themselves, and that a method of study which is of the highest importance in determining the homologies of the wing-veins in many other insects, is of little use here for this special purpose.

We have pointed out a striking difference in the tracheation

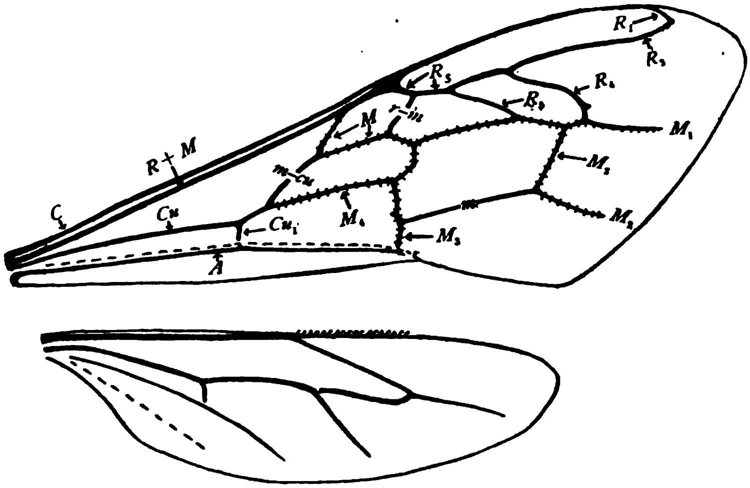

FIG. 48. — Wings of a young pupa of Apis.

of the fore wings of Tremex and of Apis. An equally striking difference may exist between the fore and hind wings of the same insect. Thus in the pupa of Tremex (Fig. 46) the main stem of the radial trachea traverses the subcosta in the fore wing; while in the hind wing it retains its primitive position. In more specialized members of the order, as in the Ichneumon-flies, even less of the primitive arrangement of the tracheæ is preserved. But a further discussion of this phase of the question would not be profitable here.

XI. THE VENATION OF THE WINGS OF EMBIIDÆ.

The systematic position of the family Embiidæ is a question regarding which there is much difference of opinion. We do

not purpose to discuss this question here beyond pointing out that in the structure of the wings there is little in common between these insects and the Blattidæ and Mantidæ, with which they have been associated by Brauer,[1] or with the Termitidæ or Psocidæ, with which they are grouped by Sharp.[2] If we were forced to decide regarding the rank of this family from a study of the wings alone, we would be obliged to regard it as representing a separate line of development of ordinal value. But in this place we wish merely to offer a suggestion regarding the probable homologies of the wing-veins.

Fig. 49 represents the fore wing of Oligotoma and is based on a figure by Wood-Mason.[3] If this figure is correct, there is little difficulty in recognizing the principal veins. The only

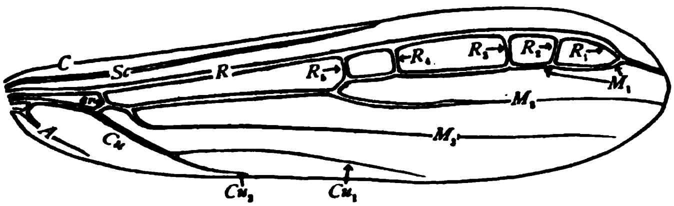

FIG. 49. — Wing of Oligotoma.

difficulty is presented by the four transverse veins on the distal half of the wing. After what we have seen in the wings of Diptera and of Hymenoptera, the most obvious interpretation of these is that they are branches of the radius, the tips of which coalesce with vein M_1. The result of this coalescence is that these veins have come to appear like cross-veins, as do veins R_4 and R_5 in the Hymenoptera. There is this striking difference, however: in the Hymenoptera only two branches of the radius bend back and unite with vein M_1; in the Embiidæ all of the branches of the radius are modified in this way. And in the Embiidæ there is no indication of a similar backward bending of the branches of the cubitus.

ENTOMOLOGICAL LABORATORY,
CORNELL UNIVERSITY, January, 1898.

[1] Friedrich Brauer, *Systematische-zoologische Studien*, p. 126.
[2] *The Cambridge Natural History*, vol. v, p. 342.
[3] *Proc. Zoöl. Soc. London*, 1883, p. 628.

ON THE CLASSIFICATION OF CILIATE INFUSORIA.

DR. V. STERKI.

AFTER so eminent a naturalist as Bütschli has modified Stein's system of Ciliata, it may appear rather assuming if I venture to propose some changes. It is done because my views have long been held, and have been confirmed as the years passed.

In the first place, it seems that the Peritricha are of an organization quite different from that of all other ciliates. The formation of the anterior part, peristome, mouth, etc., is unique, although having some resemblance to that of the Stentorina. There is no adoral zone with transverse rows of cilia like that in Heterotricha and Hypotricha, as has recently again been asserted by Delage et Herouard.[1] The arrangement of the muscular elements in the ectoplasm, or myonems, is quite different. The formation of a temporary posterior girdle of cilia for locomotion, in the most typical Peritricha, and even the permanent one in some others, is a very distinguishing feature. And a distinction of highest order is their mode of fission in the longitudinal axis,[2] or by gemmation. This character has been explained in various ways, and some have tried to bring it in conformity with the transverse fission in the other groups. Nevertheless, it remains different, and shows, combined with the other features noted above, that this group is of quite another type, or phylum, the more so if we add the peculiar phenomena of conjugation. The remaining Ciliata differ from the Peritricha in regard to these characters, and they resemble one another in respect to the most significant of them.

[1] *Traité de Zoologie Concrète. I. La Cellule et les Protozoaires.* Paris, 1896, p. 452.

[2] It must be noted, however, that in all groups the direction of the division is across that of the myonems.

In opposition to the Peritricha, we may give to this second group the name Pantotricha. Among the latter, those forms having a true adoral zone with a distinct beginning and end at the mouth entrance, and bearing transverse rows of single cilia, that is, the Hypotricha and most of the Heterotricha, evidently are of a common type, and range in one group, which I propose to name Zonotricha. True, the extreme forms are very different, *e.g.*, a Stentor on the one hand, and a Stylonychia or Euplotes on the other. But it is well known that both series, by gradual changes, in fact, run together, and that there are forms which may be ranged with one or the other. Many Peritricha are quite depressed, while there are Oxytrichidæ nearly terete, showing little differentiation of the dorsal and ventral faces, with fine and densely set cilia over most of the body (Strongylidium). And such forms as Stichospira[1] make the distinction still more illusory. Tactile hairs (or "dorsal cilia") are wanting in some of the Oxytrichidæ as well as in Euplotidæ and Aspidiscidæ. Longitudinal differentiation in the ectoplasm of Urostyla, etc., comes very near the myonems in Peritricha. With the Zonotricha range Halteria, probably also Strombidium and Gyrocoris. A rather aberrant group, falling under the same head, are the Ophryoscolecidæ, with their retractile peristome.

After removing these forms, the Oligotricha, *i.e.*, mainly the Tintinnidina, make a more uniform small group, characterized by the circular uninterrupted zone bearing cilia of a different form and type, inside of which the mouth is situated.

The Gymnostomata have been made by Bütschli a group of highest order, equal in value with all the other groups combined. It has been shown above that in a number of essential features they differ from the Peritricha and are in harmony with the other Pantotricha, and they are especially so with the Aspirotricha. Yet the formation of the mouth, together with some other characters, is so significant that it does not seem natural to reunite these two groups into the old order Holotrichida, as the French authors have done (*loc. cit.*, pp. 430, 452).

[1] See the writer's article, this journal, vol. xxxi, No. 366, June, 1897, pp. 535–541.

In the great diversity of the formation of the body among the Gymnostomata we have an interesting analogue with an equally wide range among the Zonotricha.

The highest position must be assigned the Oxytrichidæ and Euplotidæ. Here the differentiation of the main feature of the ciliates, the cilia, reaches its maximum, not only morphologically, but also physiologically, combined with the highest development of intellectual faculties, as far as we dare speak of such. In all these points the Peritricha, which have often been placed at the head of the class, are inferior. And their inferiority is demonstrated also by the fact that at least half of them are epizoa, or commensals ; a large number of animals of both categories live in colonies, either actually coherent or close together, modes of life which are not so much different as is commonly supposed.

The groups Peritricha,[1] Gymnostomata, Aspirotricha, Oligotricha, and Zonotricha seem to have the significance of orders of about equal standing with "orders" throughout the animal kingdom. Thus we would have the following table :

SUBCLASSES	SUPERORDERS	ORDERS
Peritricha		Peritricha
Pantotricha	Gymnostomata	Gymnostomata
	Trichostomata (em.)	Aspirotricha
		Oligotricha (em.)
		Zonotricha

The Ciliata here are regarded as a class. To this point, a little digression may be excused. Why should not both Ciliata and Suctoria be treated as classes? Conceded that Bütschli is right in regarding the tentacles as mouths, and I believe so, that would not necessitate ranging them together. The possession of cilia by the Acinetina, in the early stages of development, has possibly been overestimated. How many features are shown, in the earlier or larval stages of other and higher animals, to disappear at a later period, *e.g.*, cilia in Mollusca (velum) and Echinodermata? If an amœboid stage, or the development and disappearance of flagella, were accorded so

[1] The Peritricha might probably be divided into two orders; but, since I have not seen Licnophora and Kentrochona, the question is left open here.

much significance, how should we then, with good reasons, regard the Rhizopoda, Sporozoa, and Flagellata as so many classes? The close resemblance of the phenomena of conjugation in the Ciliata and Suctoria are certainly significant; but we have essentially identical ways of fecundation, etc., of the ova in different main groups of Metazoa. In their definite formations the Ciliata and Suctoria are as much different from each other, or much more so, than, for example, the classes of vertebrates and arthropods. The question seems to be rather one of logic: if the Suctoria, in their definite stage, are to be considered a degenerated type of Ciliata, they must be ranged under the same head, as a subgroup; if not so, they may well rank as a class at the side of the Ciliata.

New Philadelphia, Ohio,
April, 1898.

EDITORIALS.

A War of Extermination. — The Second Annual Report of the New York Zoölogical Society contains a graphic and startling report on an inquiry into the destruction of our native birds and mammals, made by Mr. W. T. Hornaday, the Director of the Society's Park. Observers in every state and territory were asked whether a decrease of these animals was noticeable in their locality, and, if so, what the causes were and which species were most affected. From nearly two hundred replies the conclusion is drawn that, in the thirty states reporting a decrease, there is a diminution in the number of birds, as compared with fifteen years ago, of fifty per cent. The results concerning mammals are equally startling, and the list of the better-known mammals on the verge of extinction includes seventeen species. The replies indicate that sportsmen, boys who shoot and who collect eggs, market hunters, and milliner's hunters are chiefly to blame. The most outrageous perversion of the sportsmen's instinct is seen in the atrocious "side hunts," in which a graded count is put on all the different kinds of birds and mammals killed, such as squirrels, chipmunks, chipping sparrows, nuthatches, blue jays, and woodpeckers. In one of these "side hunts" forty adult men secured in a few hours 212 gray squirrels, 210 red squirrels, 56 partridges, 25 blue jays, 41 woodpeckers, 6 owls, and so on; altogether 565 active, beautiful wild animals slaughtered in one day in one locality to make counts! Truly there is only one other mammal with which such men can be compared, and that is the tiger, which kills not for food, but for the love of killing. This is an evil which must be cured at once, or the remedy will be applied too late. Societies, sportsmen's clubs, and legislatures are beginning to make feeble attempts at control; but a more thoroughgoing, far-reaching organization is necessary to secure uniform action throughout all the states regulating the destruction of wild animals and providing for an enforcement of the laws. In the absence of such legislation, circulars cannot be relied on to influence "sportsmen" so thoughtless of the practical needs of agriculture as well as the equally important esthetic needs of human beings who love nature. Personal influence must be exerted everywhere by friends of the cause to save the remnant of our mammalian and avian fauna. As a campaign document get the Report from Mr. Hornaday, 69 Wall Street, New York City.

Zoölogy in Japan. — The completion of the first volume of the *Annotationes Zoologicæ Japonenses* enables us to see clearly the present direction of zoölogical science in that country. As is to be expected, systematic work predominates, and, naturally, the first duty of the Japanese to the science lies in this line. It is interesting, however, that marine invertebrates are more the objects of attention than those of the land, instead of less, as in European countries. This reveals the morphological training of those who are conducting or guiding investigations. Embryology is represented by Nishikawa's study on the migration of the eye in a flatfish, Ikeda's study on the development of Rhacophorus, and Hatta's on the Pronephros. Cytology is represented by Aida on the growth of the ovum in Chætognaths. In experimental work we have Yasuda's studies on accommodation of Infusoria to dense solutions.

The Diagnostic Characters of Birds. — *Apropos* of the letter of "Zoölogist" in the March number of the *American Naturalist*, Mr. Frederic A. Lucas calls our attention to a passage in his paper on the Cœrebidæ.[1]

After speaking of the difficulty of determining the affinities of this group, he goes on to say: "Of course our trouble lies in the fact that the so-called families of Passeres, at least very many of them, are not families at all, or not the equivalents of the families of other groups of vertebrates. It is my belief that any group of vertebrates to be of family rank should be capable of skeletal diagnosis, and this test applied to the Passeres reduces them to a family or two, as has been done by Huxley and Fürbinger."

In his letter Mr. Lucas says that "for family one may equally well read genus. The groups of birds are nearly all pitched on too high a key, the orders being families (to a great extent), families, genera," etc.

[1] F. A. Lucas, Notes on the Anatomy and Affinities of the Cœrebidæ and other American Birds, *Proc. U. S. Nat. Mus.*, vol. xvii, No. 1001, pp. 299–312, 1894.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

A Study of Hawaiian Skulls.[1] — The collection studied contains sixty-five crania. One series is from the lava caves and represents the dominant race of the Hawaiian Islands, and the other is from the sands of the coast where the common people were buried. Dr. Allen states that it is impossible to say to what extent the differences between the two series are due to differences of caste, and how much is due to the fact that the coast series is more recent than that from the caves, and has been more affected by imported diseases. The number of skulls in each group is comparatively small, so that on the whole the differences shown are of doubtful importance. The value of the paper lies in the methods employed rather than in the contrasts shown between the two types of crania. The descriptive method is given much less prominence in this study than in the author's memoir on the Crania from the mounds of Florida. It is stated in the preface that the method by measurements, "all things considered," is the most fruitful. The differences in anatomical variation are expressed in percentages rather than by perplexing Greek compounds.

A few of the dimensions are charted on quadrille paper by the "terrace" method of graphic delineation, an innovation in craniometry. The advantages of broken over curved lines are obvious. We believe that other devices in common use by statisticians might be employed with advantage by craniologists, *e.g.*, the average, minimum, maximum, and relative amount of variation may be clearly and easily shown by simple bar diagrams. Craniology concerns itself largely with the study of variation, and the numerical expression of this, while precise, conveys little meaning to the uninitiated.

Dr. Allen's paper emphasizes the fact that there are other problems than those of race for the consideration of the craniologist — in the closing words of the author: "I remain of the opinion that the interest attached to the study of the human skull is not confined to attempting to limit race, but to the study of the effects of nutritive and even morbid processes upon the skull form."

[1] Harrison Allen, A Study of Hawaiian Skulls. *Trans. of the Wagner Free Inst. of Sci.* Philadelphia, 1898.

The Winter Solstice Ceremony at Walpi.[1] — In his address before Section H at the Detroit Meeting of the American Association for the Advancement of Science, Dr. Washington Matthews said: "I believe, as a result of an extensive experience, that ceremony offers material for the study of human development equal to that offered by art, government, legend, or any other subject of ethnologic investigation" (*Journ. Am. Folk-Lore*, vol. x, p. 258). This material is being utilized by an increasing number of ethnologists, among whom Dr. Fewkes is one of the most active workers.

"The two solstices are marked epochs in the ritualistic life of the Tusayan Indians," but the ceremonies observed at the Winter Solstice are the more important. The account of these ceremonies, witnessed at two of the five villages practicing them, is given in detail. The author states that the ritual is the result of growth by composition and mutual reaction, and that it will prove to be "particularly instructive to the student of the migrations of the ancient peoples of Arizona, especially those of the Sun and Rain Cloud clans, which, it is claimed, came to Tusayan from the far south."

The value of the paper is enhanced by the addition of a bibliography of the extensive literature by the author upon the elaborate "ceremoniology" of the Tusayan pueblos.

F. R.

GENERAL BIOLOGY.

Regressive Evolution in Biology and Sociology.[2] — The well-known authors associated in this work contribute special knowledge in their respective departments, with the aim of elucidating especially the phenomena of vestiges in sociology from the facts of biology. Between the sciences of facts, indeed, a marked parallelism can be traced.

The work considers first regressive evolution generally, and the conclusion is drawn that all transformations of organs and institutions are accompanied by regression, and that, since all the higher organisms contain reduced organs, and all social institutions contain survivals, regressive evolution is universal.

Regression does not proceed backward along the same path as

[1] J. Walter Fewkes, *American Anthropologist*, vol. xi, p. 38.

[2] J. Demoor, J. Massart, et É. Vandervelde, *L'Évolution regressive en biologie et en sociologie*. Paris, Alcan, 1897, 324 pp.

that which development had pursued; also, it is not reversible — that is, an organ once lost cannot reappear, nor can a degenerate remnant again fully develop.

Regressive evolution is caused by the limitation of the means of subsistence — food, capital, or forces for work. In biology it has for its principal if not its only factors, the struggle for existence between the organs and the struggle for existence between the organisms. In sociology artificial selection plays a preponderating rôle, natural selection a secondary one. The occasional causes of regressive evolution are inutility of function, the insufficience of nutrition or of resources, and, in biology alone, the lack of room. An institution or an organ which has ceased to be functional and has lost all utility, direct or indirect, persists, however, if one or other of the factors of atrophy, variability, or selection is not at work.

The book is written in an interesting, somewhat popular style, and is illustrated by numerous figures in the text.

ZOÖLOGY.

The Mammals of Florida.[1] — In Mr. Bangs's recent account of the mammals of peninsular Florida and the coast region of Georgia we have the first attempt at an exhaustive enumeration of the mammals of a definite geographical area from what may be termed the point of view of the new era in the history of North American mammalogy. It therefore gives a good opportunity of contrasting the new with the old in this field of research. Of papers based on large collections of mammals from restricted areas, and also of monographic reviews of particular groups, there has been no lack in recent years, but none has before attempted to treat exhaustively the mammalian fauna of a well-defined and considerable area.

It is needless to say that Mr. Bangs approaches his subject from the radical point of view of the "new school," and it is therefore of interest to contrast our knowledge of to-day, as here reflected, of the mammalian fauna of Florida with that of, say, twenty years ago. Fortunately, Mr. Bangs's "Comparative Table" of the principal previous lists of the mammals of the region under review renders

[1] Outram Bangs, The Land Mammals of Peninsular Florida and the Coast Region of Georgia, *Proc. Boston Soc. Nat. Hist.*, vol. xxviii, No. 7, March, 1898, pp. 157–235, with text cuts.

such comparison easy. Up to 1883 (1871–83) only 35 species were recognized from the region in question; this number is now raised by Mr. Bangs (including numerous subspecies) to 73. Five of these, however, are from the coast region of Georgia, only 68 being enumerated as Floridian.

"The coastal strip of Georgia and northern, central, and southwestern Florida agrees very closely in general conformation, and also in faunal and floral characters." The general surface of the country is "flat and monotonous, with a light sandy soil and interminable forests of pine." The coast region of Georgia and northeastern Florida, south to Matanzas River, "is one continuous stretch of salt tide-marsh interlaced by deep creeks, and now and then broken by a sandy beach where some higher point of land meets the deep water." Along this coast is a series of islands, some of the larger of which, as Cumberland Island, Georgia, and Anastasia Island, Florida, and some of the Florida Keys, though separated so slightly from the mainland, appear to have developed a number of well-marked insular forms, the discovery of which has done much to increase the list of species now recognized from the general region. But aside from this, peninsular Florida, which is subinsular in position and environment, has furnished in recent years not only many new species and subspecies, but some forms so distinct from any previously known as to fairly entitle them to rank as new subgenera. The increase in the list of recognized forms is thus only in part due to the fine discriminations it is possible to make by aid of the greatly increased and vastly better condition of the material now available for study, as compared with even a decade ago, but to the thorough exploration of what appears now to have been, up to within a very few years, a very imperfectly known region, mammalogically speaking.

But this was not only the case with Florida, but with North America at large, not excluding even the long-settled parts of the eastern states. Most of the smaller mammals are chiefly nocturnal and more or less subterranean in their habits, and formerly, even as late as fifteen years ago, their capture was largely a matter of accident, and series of specimens of any but the most common species did not exist. Then, too, their preparation was so faulty as to greatly impair their value for study, and measurements taken from the animals "in the flesh," or before skinning, were rarely available. But of late all this has been changed; the trapping and preparation of small mammals have been reduced to a science, so that certain kinds of mammals it was formerly thought almost impossible to

capture, from their supposed rarity or obscure habits, can now be had in any desired numbers with a certainty and ease not dreamed of in earlier days. To this change in resources is due the recent great advance in our knowledge of North American mammals, of which Mr. Bangs's report on Floridian mammals may be taken as a fair index.

Among the more notable recent additions to the known mammalian fauna of Florida may be mentioned the large water vole, described by Mr. True in 1884 as *Neofiber alleni*, it being then considered as the type of a new genus, but now referred as a subgenus to *Microtus* (formerly *Arvicola*). Although known for several years from only two or three specimens, it was taken in considerable numbers in eastern Florida in 1889 by Mr. Chapman, who was the first to make known its interesting life history,[1] and to whose paper Mr. Bangs fails to make reference in his extended comment on the species. In view of its present known wide distribution in eastern and interior Florida, its comparatively large size and easily recognized presence, the late discovery of this species, as remarked by Mr. Bangs, is one of the strangest facts in the history of American zoölogy.

Another almost equally interesting discovery is that of the big-eared Florida deer-mouse (*Peromyscus floridanus*), described in 1889 by Mr. Chapman from a single immature specimen, and redescribed in 1890 from an adult individual by Dr. Merriam. This is the largest and biggest-eared deer-mouse of Eastern North America, and though known for some years from only two or three specimens, it has since been found to be a common species over a considerable area, and is now well represented in collections of Florida mammals.

Almost equally interesting is the white-bellied Florida deer-mouse (*Peromyscus niveiventris*), described also by Mr. Chapman in 1889, this being as much smaller than previously known deer-mice from Eastern North America as the big-eared species just mentioned was larger. It is also otherwise peculiar, and proves to belong to a group restricted to Florida, of which three species and two additional subspecies are now recognized by Mr. Bangs, one of them being insular (*P. phasma* Bangs, Anastasia Island).

There are numerous other forms worthy of note, but space will suffice only to say that to the 35 species known from this area prior to 1884, 38 species and subspecies have been added since that date, 30 of which have been described as new, all but two within the last ten years, including 16 described by Mr. Bangs in the present paper.

[1] *Bull. Am. Mus. Nat. Hist.*, vol. ii, June, 1889, pp. 120–122.

Eight species previously described, but not then known from Florida, complete the 38 additions, more than doubling the list. The names of 12 others have been changed through the recognition of the Florida phase of wide-ranging species as subspecifically distinct from the species formerly recorded as Floridian, so that the total number of new forms from Florida and the coast region of Georgia described, with two exceptions since 1888, is 42, out of a total of 73. Excepting among the bats, nearly all of the old species have been split into one or more subspecies, while the representatives of some of the genera have greatly increased. For example, *Geomys* (pocket gophers or "salamanders") has increased from 1 species to 4, with an additional subspecies; *Peromyscus* (deer-mice), from 3 species to 8 species and 3 additional subspecies.

Some of the subspecies recognized by Mr. Bangs are only very slightly differentiated local forms, so slightly that the advisability of their recognition in nomenclature is, to say the least, in some instances doubtful.

Mr. Bangs's paper is an important contribution to North American mammalogy, and is of especial value as a contribution to the faunal literature of a peculiarly instructive and interesting region.

J. A. A.

Frog Biography. — That most useful animal, the frog, has been so thoroughly discussed in such works as those of Ecker, Marshall, and Morgan, that it might seem at first sight as if there were nothing more to be said beyond the completion of anatomical and embryological details.

The first of a series of natural history notes [1] made upon Amphibia by H. Fischer-Sigwart, presents so much of interest in the life history of the frog, *Rana fusca*, that we wait eagerly for more, and, at the same time, venture to hope that some American representative of this group may soon meet with as sympathetic a biographer.

The author's observations extend over a period of some thirty years; the past ten years furnishing continuous data of times and seasons and measurements, made in the field and in his "terrarium," and now collected in tables. These and the double-page plate (the artistic merit of which must be seen to be appreciated) may be passed by to begin a brief synopsis of some of the facts recorded.

Scattered over the country, far from the water, the frogs of this species pass the summer in feeding, being most active by night and

[1] *Vierteljahrsschrift d. Naturfor. Gesell. in Zürich*, January, 1898, pp. 238–313.

lying concealed by day. After the middle of summer their appetites grow less keen, and as autumn comes on they begin to leave the special hunting fields that each has held for itself, and to migrate, singly, toward the ponds and lakes. It is, however, only the sexually mature animals, four or five or more years of age, that thus migrate; the young ones remain. The adults pass the winter concealed about the shores or in the mud at the bottom of the ponds, and awake from the dormant state when the early spring thaws out the ice. This occurs in March or February in the lowlands, but high in the mountains perhaps not until the middle of summer.

The awakened frogs congregate in great numbers and fall an easy prey to the greatest of all their numerous enemies, man; before they were decimated by wholesale slaughter at this, their breeding season, a single fisherman might take 1500 frogs in a single day.

The males, which we infer are much more numerous than the females, clasp the females and passively suffer themselves to be carried about in the water, or even upon land, for several days — three to thirty, in different places and seasons. Whether the males use their vocal organs to produce their "purring" noise or not seems to depend upon the temperature, and their use in warm weather indicates, the author thinks, a cat-like state of content. In cold seasons these sounds may not be heard, though breeding continues as usual.

The actual spawning is accompanied by a maximum of excitement when the females, covered by a struggling mass of males, sink to the bottom of the ponds and there deposit their eggs. Each egg is 1½ to 2 mm. in diameter, black above and white below, and enveloped in a lump of jelly 4 mm. in diameter. The eggs deposited by a female form a cluster about as large as a hen's egg, and these clusters stick together so that a gelatinous layer may be formed on the bottom of the pond, extending, in some cases, as a band a meter wide all along the shore.

This breeding season lasts on the average 134 days, from the first awakening to the completion of spawning, and during that time the frogs take no food — unless, sometimes, their skins! The skin comes off in shreds, in the water, at this season, and is shed again three times during the year. In these moltings the animal may eat its own skin.

When the eggs are laid and fertilized, the frogs all leave the ponds suddenly in a single night and gradually return to summer hunting grounds far from the water.

The gelatinous masses left on the bottom of ponds swell and rise to the surface after a few days, and later sink 20 to 30 cm., where they hang suspended. From the size attained by the jelly-capsule surrounding each egg one may judge of the length of time the eggs have been laid. The eggs hatch after 6 to 19 days (about 10½ days in the terrarium, and 12½ to 13½ in the ponds outside). The larvæ form a jet-black mass on the egg-jelly, and then swarm about over it, and in two or three days scatter and hang attached by their adhesive organs to floating leaves and to plants. After a week their external gills are gone, and they have taken on the well-known "tadpole" proportions. The jelly floats about and dissolves away.

The tadpoles develop their hind legs in 55 to 60 days after hatching, when 38 to 44 mm. long; and both fore legs when 70 mm. long. They eat anything that is soft, chiefly decaying vegetable matter; are very fond of putrid veal, and thrive well on earthworms in a similar state. After 79 to 81 days, when 45 to 50 mm. long, the tadpoles transform into small frogs.[1]

These young frogs all leave the water immediately, and after a few days move away from the shores of the ponds to scatter abroad, each settling in some separate hunting ground, there to remain four years or more, till sexual maturity calls them back to their native pond.

At the first the young frogs are 15 to 20 mm. long; they grow to be 25 mm. long the first season, 30 mm. the second year, 50 to 55 mm. the third, 60 mm. or more the fourth, and 70 to 80 mm. the fifth, when they are sexually mature.

Kept in captivity they soon grow fat and dull (*i.e.*, tame), and furnish to careful observation some facts of interest to comparative psychologists, though it cannot be said that they give much evidence of high psychic activity.

Later, when these snakes were removed, the frogs no longer exhibited alarm at a stick. This snake seems to hypnotize the frogs so that they make no resistance but allow themselves to be swallowed, while they will flee from some other snakes. They seem also to recognize this enemy by its odor, if we accept the author's evidence.

They learned to come to a certain place to be fed at a certain time, and, after wandering about in the night time, came regularly back to some habitual resting place to spend the day.

They fed most voraciously, eating even hornets without great

[1] In one case all the eggs of a bunch were white and produced albino tadpoles, with dark eyes, however; but these became brown and changed into frogs but little lighter than normal.

inconvenience, and using their hands to force the ends of large earthworms into their mouths. They could be made to take meat and even carrion held on a needle before them. In this way the captive frogs were made much more fat and larger than those of the same ages outside.

Such overfed creatures developed a second period of sexual excitement in midsummer, but this led merely to certain males grasping the females for a short period.

Observations made in the neighborhood of Zofingen, Switzerland, and upon a frog not found here, may have no direct bearing upon the life history of our own frogs, but they indicate lines for imitation. With increasing interest in aquaria and gardens, both botanical and zoölogical, we may hope for more natural history work of this kind, and for the filling up of immense gaps in our knowledge concerning the length of life and rate of growth of animals. E. A. A.

Psychical Qualities of Ants and Bees.[1] — The question as to whether or not we may ascribe psychical qualities to ants and bees is discussed by Albrecht Bethe in a recent issue of *Pflüger's Archiv.*

In his introduction the author points out the danger of an investigator's personality being read into the subject investigated, and also danger of the use of such words as carry with them meanings not warranted by the facts; men see, but all we know about bees is that they are influenced by light, and it would be unscientific to say they do anything so highly psychical as seeing until it is proved. It is absolutely impossible to find words which are always consistent with this idea, but the endeavor has been made to do so as far as possible.

The polymorphic colonies of bees and ants are pointed out as giving direct evidence against the Lamarckian principle of the inheritance of acquired characters. This polymorphism, Bethe believes, is completely explained through congenital diversity and natural selection, as is true also for all purposeful reflexes.

It is well in reading the paper to bear in mind the author's distinction between reflexes and instincts. "Only those actions can be designated instinctive in which an animal, which can be proved to possess psychical qualities, follows an inherited impulse without a

[1] Albrecht Bethe, Dürfen wir den Ameisen und Bienen psychische Qualitäten zuschreiben? *Archiv f. d. Ges. Phys.*, vol. lxx, Pts. i, ii, pp. 15–100, January, 1898.

previous process of learning, in which the action is not purely reflex, but is eventually regulated through psychical processes"; "sexual intercourse is instinctive in man, but is a reflex in beetles. A silkworm spins its cocoon reflexly, but a bird builds its nest instinctively. Instincts are neither wholly reflex nor wholly psychic."

Individual diversity extends farther than is generally supposed; even the odors given off by individuals are characteristic, since through them bloodhounds are able to follow one trail unerringly.

The first one of the two main divisions of the paper is devoted to a research on ants, and the first question asked is:

"Do ants of one colony recognize each other?"

From the fact that an ant, if placed on a nest (not its own) of either the same or a different species, will be seized and often killed, it has been concluded that they know each other personally and distinguish between strangers and their own number, although some nests contain thousands of individuals.

Lubbock investigated this subject and found that:

1. After a separation of almost two years, individuals of *Fomica fusca* were received in a friendly manner when placed back on their own nest.

2. Pupæ, separated from their nest but cared for by workers from it, were received in a friendly manner without exception if placed back when grown.

3. If pupæ were cared for by workers of another nest, it was different. Out of forty-four placed on their own nest, seven were attacked and thirty-seven received. Of fifteen placed on the foster worker's nest, all were attacked.

4. An egg-laying queen was taken from her nest, and her subsequent brood when grown was not seized when placed on the nest. These results led Lubbock to believe that there is no personal recognition among ants of one nest; and from the fact that chloroformed ants were received by their own fellows but seized by individuals of a strange nest, he concluded that reception or rejection did not depend upon any sign or word, but what was at the bottom of the matter he did not understand.

Romanes thought their methods of distinguishing each other were not capable of being understood by us, but that it was, through some kind of psychical process, a species of memory.

McCook, observing that after an ant had fallen into water it was attacked when coming home, concluded that through the bath the ant had lost its peculiar odor, hence was no longer recognized.

Forel found that ants of different nests could be brought together without one seizing the other, provided the antennæ be first removed. He held that the sense of smell was located in the antennæ, and that it is through this sense that ants of the same nest are recognized.

But unless it had been shown that each ant learns in its individual life to answer the smell of its own nest fellows in a friendly, and that of strange ants in an unfriendly, manner, and that it does not do this *ab-ovo*, it is not proved that we are dealing with "knowledge" or "thought."

An ant smeared with an extract of the bodies of its own nest fellows is received when placed on its own nest, but seized if smeared with an extract of strange ants. This was tried in several cases and held true in each.

An ant if first bathed in 30% alcohol, then with water, then smeared with the extract of another species, will be received by the colony from which the extract is made. From the fact that the strange ant may be many times larger than those among which it is introduced and of a different color, it is proved that *form* or *color* plays no rôle, but as the presence of a strange ant disturbs them when several millimeters away, it would appear that a volatile chemical material is concerned in the different reaction of ants toward their fellows or toward strangers. If the ant be washed with 30% alcohol and water, and as soon as dry returned to the colony, it will be seized, but if kept away twenty-four hours and then returned, the colony will receive it. From this and Lubbock's experiments it is shown that this volatile material, which is called "Neststoff," is alike for individuals of the same nest, and every nest has its characteristic "nest material," which is produced by each individual.

Young ants, of a *Lasius nigra* nest, which had never met a stranger, were allowed to mature and harden in a box, then some were placed on a nest of Tetramoria, which were thrown into the greatest unquiet; some were placed on their own nest, where they ran quietly among their nest fellows. A few Tetramoria were placed in the box with the remaining ants, and the Tetramoria were at once attacked. Nothing here had been learned but that the different reactions toward like and unlike "nest materials" are inherited. Like material (that produced by ants of the same nest) constitutes no stimulus, but unlike "nest material" calls forth a reflex of either fighting or fleeing, depending on the amount present.

Ants, if confined in a gauze box on their own nest, will not be noticed but allowed to starve. Ants of another nest placed in the

same box will call out the fighting reflex of dozens, which soon surround it, endeavoring to get in. The relative amounts of the two "nest materials" seem to determine the reflex. The actions usually explained through "love," "compassion," or "hate" are better explained on purely physiological grounds.

In pupæ the "nest material" is not yet differentiated, for all pupæ will be eagerly accepted by all ants. As the pupæ grow, their "nest material" mixes with that of the foster colony and the whole is modified. A colony of more than one species is thus formed, examples of which are found in slave-making ants. The slaves of a nest will not be received if placed in the nest from which taken. They do not know their masters, nor do the masters know the slaves. They have become one colony through the mixing of their "nest materials."

From the foregoing it appears that the different reactions of ants toward individuals of their own and different nests depend on reflexes.

The next question that the author considers is:

"How do ants find their way?"

It is generally thought that ants know the region about the nest, and orient themselves when going about by familiar objects, either through sight or smell. They travel on paths, and when off the path are lost until it is regained. Some sugar was placed on a blackened paper in front of a nest. The first foraging ant did not find the sugar; the second ant, after making many curves, zigzags, and loops, found the sugar, took a grain and retraced its steps, but cut off the loops. Before it had reached home a third ant had come to the place on the paper where No. 2 had left it, followed its track to the sugar, and returned the same way; and all ants which came near this path followed, each straightening it, however, by an antenna's length, until in an hour or two there was a straight path between the nest and the sugar. None followed the unsuccessful trail. It would appear from this that not only is a track left which may serve as a guide to other ants, but which is of such a nature as to indicate the outcome of the expedition. The paths were followed as well when covered with black paper tunnels as if left well lighted, but a strip of paper 5–10 mm. wide laid flat across a path would bother the ants greatly. They would stop on reaching the paper, become very unquiet, several would collect on both sides, but none would cross over; some would turn and go back, some try to crawl under the paper. Something is deposited on the path which guides them, the volatile nature of which is shown by the fact that if the strip of paper is allowed to remain

until the path is well established across it and then removed, the space from which it was taken becomes as great a hindrance as the paper when first laid down. The drawing of the finger across a path leading over a glass plate will cause the same result as the paper strip. In the first case the guiding material is covered up, in the second it has passed off naturally, while in the last it has been wiped away.

Loaded ants, even if picked up, rotated, and placed on the path backward, always go toward the nest. A path was led across a board, a section of which could be reversed, thus making a part of the path lead in the opposite direction from which laid down. When reversed, the next ant on coming to the section from either direction would stop, flourish its antennæ over the path, run first to one side and then the other, but would not proceed. If the section was not reversed until the ant was on it, the ant would continue on its way across the section, but on coming to the place where the section ended, instead of going on it would act as described above. These and other similar experiments leave little doubt that there is a polarization of the guiding material; but to say it is polarized does not explain all phenomena. Unless the ants walked home backward or deposited the material backward while coming home, there would be nothing present to indicate the direction of the nest. One experiment showed, however, that outgoing ants follow the paths of incoming ants with difficulty, and *vice versa.* This indicates the existence of two different guiding materials in the same path, one an incoming guiding material, the other deposited by outgoing ants.

Lubbock thought that he had proved that ants communicate with one another, but Bethe uses one of Lubbock's own experiments to show that it proves nothing. If a handful of pupæ placed on a piece of paper near the nest be found by an ant, soon numbers of ants will be carrying the pupæ home; but if an ant be carried to the pupæ and when it has taken one, it be aided to find its way home and so on for several trips, using the same ant each time, no other ants ever find the pupæ. In the latter case no path is laid down *to* the pupæ, hence there is nothing to guide the ants to them, while in the former experiment they had a path to guide them. All of Bethe's experiments to ascertain the presence of any communication between ants could as well be explained through simple physiological stimuli as through intelligence.

Several experiments, calculated to call out the intelligent action of ants, should they possess such even in the most meager degree, were carried on, but all with negative results.

The second half of the paper is devoted to a research on bees. Do bees of one hive recognize one another?

. Bethe finds that they, like ants, do not know individuals either by sight or smell, but that, *ab-ovo*, they react in a friendly manner toward their own colony "nest material," and in an unfriendly manner toward a "nest material" of bees of other hives. As with ants, two "nest materials" may be so mixed as to become one, as is shown by the method necessary in introducing a new queen into a queenless colony. If unprotected she is at once killed. If, however, she is put among them for a few days, protected by a gauze box, and then liberated, she is received. At first her "nest material" calls out the fighting reflex of the hive, but given time the "nest materials" of both mix and cease to afford any adverse stimulus. That the difference in the "nest materials" of two hives is produced by congenital diversity is shown by the following.

A hive was divided, half the grubs of the old being given to the new hive. In a few days, when these young bees had come out, some were taken from the old hive to the new, and were treated as belonging to the new hive. For two or three weeks bees of one hive could be placed in the other and be well received, but after this time the brood of the new queen began to come out. One of these new bees introduced into the old hive would be killed, and bees from the old hive would be attacked by the new brood of the new hive. Old bees of the new hive if isolated twenty-four hours were still received by the old hive, but after three weeks longer no more mixing of the two hives could be effected. The "nest material" from the new queen had become strong enough to modify that of the whole hive.

How do bees find their way?

They could not leave a material in the air, as is left by ants on their paths, which could guide them to and from the hive, but since a male moth has been known to locate a female several miles distant, it seemed possible that still a volatile chemical material might be the agent which guides bees. A tunnel of paper placed over the entrance to the hive caused a great change in the actions of the bees; few crossed over the paper either in or out, but collected at the edge, both on the inside and outside of the tunnel, and buzzed. When it was removed there was a gush of bees, both entering and leaving the hive. A bridge of paper over the entrance caused no such disturbance, since the entrance board was left free, on which there was a material which guided the crawling bees.

If *flying* bees are guided by the "nest material" which is radiating

from the hive, then turning the hive 90° should have had no effect; but it did. The bees returned to the side where the entrance was before the turning. Thinking that the rapid turning might not have been followed by the dense cloud of "nest material" which exists immediately before the entrance, a hive was mounted on a horizontal wheel, and the whole on a truck, so that the hive could not only be turned slowly, but moved from one place to another.

When a revolution of 90° was made in fifteen minutes, the bees went in well until the 30° point was reached, after which fewer and fewer went in, until at 90° none entered the hive at all. When twenty minutes were required in turning the hive 90°, the bees went directly in until the 45° point; from this position until the 135° point was reached the stoppage of the bees increased more and more until no bees went in at the latter position.

Reducing the rate of rotation to 90° in forty-five minutes did not produce any different results from the last experiment. As the hive would approach the 180° point, the path on which the bees arrived would swing back to its old position, thus bringing the bees to the back of the hive.

If the hive was drawn back 50 centimeters from its usual position, the bees returned to the place where the entrance was, and, circling about, some would find the entrance. If drawn back 2 meters no bees found the hive, but circled about its old position in hundreds, going into a box if placed there with a hole where the hive entrance had been.

A chemical "nest material" aids somewhat in entering the hive, but does not play the chief rôle in guiding flying bees. Whatever it is seems to guide them not to the hive but to a point in space where it was when left by the bees.

To ascertain if memory pictures have any part in this, a hive was masked so that even a man would not have recognized either it or its surroundings, but so long as neither red nor white was used, no effect was noticed on the bees. These two colors, however, always seemed to disquiet them, causing a collecting, probably through their dazzling effect. This shows that no memory picture of the hive is retained, and to ascertain whether they fly through memory pictures of the region about the hive, the following experiments were made, in which the city near the Institute, in which few flowers bloom and in which a bee is seldom seen, is assumed to be an unknown region, while the meadows around the Institute are assumed to be known to the bees. In each instance eight marked bees were taken 350 meters

from the hive on quiet sunny days and allowed to fly, the hive entrance being watched 12 minutes, with the following results:

BEES FROM MEADOW.	BEES FROM CITY.
1.) Used 2⅔ minutes in returning.	1.) Used 1½ minutes in returning.
2.) " 4½ " " "	2–4.) " 2¼ " " "
No more returned during 12 minutes.	5.) " 2¾ " " "
	6.) " 3½ " " "
	Two did not return in 10 minutes.

Greater distances were employed in two other experiments, as follows:

Eight bees carried 400 m. Entrance observed 10 minutes.

BEES FROM MEADOW.	BEES FROM CITY.
1.) Used 4½ minutes in returning.	1.) Used 5 minutes in returning.
2, 3.) " 5 " " "	2.) " 7 " " "
4, 5.) " 6 " " "	3, 4.) " 10 " " "
6–8.) " ? " " "	5–8.) " ? " " "

Ten bees carried 650 m. Entrance observed 12 minutes.

BEES FROM MEADOW.	BEES FROM CITY.
1.) Used 5 minutes in returning.	1.) Used 4¾ minutes in returning.
2.) " 5½ " " "	2, 3.) " 5¼ " " "
3.) " 7 " " "	4.) " 7½ " " "
4.) " 9½ " " "	5.) " 9 " " "
5.) " 11 " " "	6, 7.) " 10½ " " "
6–9.) " ? " " "	8.) " ? " " "
10.) Did not fly from box.	9, 10.) Did not fly from box.

The bees did not see the Institute, but in nearly every case started in the right direction before flying up over the tops of the houses which were between them and the hive. Memory pictures do not seem to aid them on their homeward journey, but some unknown force, which from the following experiments seems to guide them not to the hive but to a point in space which may or may not be the one in which the hive stands or stood.

Of a number of bees carried in a box a long distance from the hive and liberated, not all returned to the hive, but some, after circling in the air for some seconds, returned to the box, which had been set on a rock before being opened.

These bees were thrown into the air again, and the box removed. This time the bees came to the spot where the box had been.

The bees were again liberated while holding the box in the hand above the ground, then stepping back some distance the bees were observed to come to the space where the box had been and to circle about it some time.

This unknown force does not operate an infinite distance, but is limited to an area the radius of which is about three miles.

In conclusion, then, the author finds nothing in the phenomena exhibited by bees or ants to prove the existence of any psychical quality. They learn nothing, but act mechanically in whatever they do, their complicated reflexes being set off by simple physiological stimuli.

CASWELL GRAVE.

Studies on Hair. — In the last number of the *Jenaische Zeitschrift* (vol. xxxi, p. 605) Dr. Fritz Römer continues his studies on the integument of mammals in an article dealing with the arrangement of the hair on the African rodent *Thryonomys swinderianus.* In an embryo of this species, about sixteen centimeters long, the head, trunk, extremities, and base of the tail seemed covered with rows of small scales. On closer inspection this appearance was found to be due not to scales, but to the arrangement of the hair. The hairs were placed in short, slightly curved rows, each row containing three, five, eight or twelve hairs. While in any row the middle hairs were longer than the lateral ones, no single, large, central hair could be distinguished, as de Meijere has found in the hair groups of so many mammals. Römer explains the rows of hairs in Thryonomys by assuming that they were originally developed on an ancestral form covered with scales, the rows of hairs alternating with the scales, and the scales afterwards disappearing. Since the publication of de Meijere's paper on the hairs of mammals this theory has been gaining ground. Beside these regularly arranged hairs the embryo examined by Römer showed many small, irregularly scattered hair germs which, upon further examination, were shown to give rise to the fine hairs of the thick winter fur, the summer fur consisting almost entirely of the regularly arranged hairs. The summer fur, then, presumably represents a hair arrangement phylogenetically older than the winter fur.

G. H. P.

The Eyes of Amphioxus. — The organs of vision in Amphioxus have been made the subject of careful study by Dr. R. Hesse.[1] They consist of very simple direction eyes, lying close to the central canal of the spinal cord. They occur from the third muscle segment very nearly to the tail. The eyes are not uniformly distributed along the cord, but are arranged in segmental groups, the groups corresponding to the muscle segments and, consequently, alternating on the two

[1] *Tübinger Zoologische Arbeiten*, Bd. ii, No. 9, 1898.

sides of the cord. While a group near the middle of the animal may contain as many as twenty-five eyes, near the anterior or posterior ends a group may be represented by a single eye only. Each eye is composed of a sensory cell, so surrounded by a pigment cell that the former is accessible to light only from one direction. In general, the eyes ventral to the central canal face ventrally, as do those in the right half of the cord, while those in the left half face dorsally. Notwithstanding these anatomical differences, the living animal shows no special response to light coming in a particular direction.

G. H. P.

Note on the Mydaidæ of New Mexico. — Prof. S. W. Williston has recently published (*Tr. Kansas Acad. Sci.*, vol. xv) some interesting notes on these curious flies. He remarks: "Collections of Diptera, even large ones, rarely include many specimens or species of Mydaidæ." They are, in general, of southern distribution, though one species (*Mydas clavatus*) occurs rarely in Massachusetts. The first species observed in our region were those taken by Captain Pope on the Pecos River, somewhere about the Texas and New Mexico boundary. No less than four species from Pope's collection were described by Loew, as *Leptomydas venosus*, *Mydas luteipennis*, *M. simplex*, and *M. xanthopterus.* Dr. Williston, in his paper cited, adds a new species, *Ectyphus townsendi*, collected by Townsend at Las Cruces, N. M.; and also records *Mydas decar* O. S., and *M. basalis* Westw., as taken in New Mexico by F. H. Snow, but unfortunately omits to say just where.

On June 27, 1897, the writer was collecting grasshoppers with Mr. A. P. Morse, of Wellesley College, in the mesquite zone back of the Agricultural College, in the Mesilla Valley. Nearly at the same time, I took an example of *Mydas carbonifer* O. S., and Mr. Morse took one of *M. luteipennis* Loew, these being the first Mydaidæ I had come across in several years' collecting. They were determined for me by Mr. Coquillett, of the Department of Agriculture. *M. carbonifer* is a black fly, well deserving its name, which seems to have a remarkable range. Osten Sacken's type was taken by Professor Comstock at Norton's Landing, Cayuga Lake, N. Y., and not only does it range south to New Mexico, but Williston (*loc. cit.*) refers provisionally to this species an example from Chapada, Brazil, doubtless collected by H. H. Smith, though it is not so stated.

M. luteipennis, which was also taken by Pope, is a large blue-black fly with red wings, so closely resembling *Pepsis rubra*, a formidable

Pompilid wasp common in the same locality, that we may regard it as a true mimic. Dr. Williston, describing another Mydaid (*Ceriomydas fraudulentus*) from Chapada, Brazil, remarks that it shows a remarkable mimicry of certain species of *Conops*, occurring in the same region. Is it not, perhaps, likely that both the *Ceriomydas* and the *Conops* mimic some Hymenopteron? T. D. A. COCKERELL.

Zoölogical Notes. — Mr. A. E. Shipley, of Cambridge, England, has a valuable paper on the species of the peculiar group of parasites, the Linguatulidæ, in the first number of Blanchard's *Archives de Parasitologie.*

In the first number of the thirty-second volume of the *Jenaische Zeitschrift* are three papers dealing with the anatomy of the whales. Dr. Friedrich Jungklaus describes the stomach in the young and in some cases of the adult of six species of Cetacea. Among his conclusions he finds a striking difference between the stomachs of the toothed and the whalebone whales, that of the toothed whales differing far more from the normal mammalian whales than does that of the mystacocœtes. On the other hand, the resemblances between the two types are regarded as the result of convergence. Otto Müller discusses the alterations which the respiratory organs have undergone in the adaptation of these animals for an aquatic life, some other aquatic mammals being introduced for comparison. Wilhelm Dandt discusses the urogenital apparatus of the Cetacea. He concludes that the great development of the kidneys is due to the watery nature of the food, since in the absence of sweat glands all water must be eliminated by the lungs and kidneys. The strongly marked lobulation of the kidneys is secondary, not primitive. In the fœtus the penis is external, but it becomes internal during embryonic life. The accounts in these three papers go far towards supporting the thesis that the Cetacea is a group of polyphyletic origin, and their resemblances those of convergence.

Proceedings of the Biological Society of Washington, vol. xii, pp. 85–114, April 30, 1898, contains Bailey, V.: Descriptions of Eleven New Species and Subspecies of Voles. Bangs, O.: A New Raccoon from Nassau Island, Bahamas; Description of a New Fox from Santa Marta, Columbia; A New Marine Opossum from Margarita Island. Merriam, C. H.: The Earliest Generic Name for the North American Deer, with Descriptions of Five New Species and Subspecies; Descriptions of Two New Subgenera, and Three New Species of Microtus from Mexico and Guatemala; Descriptions of Twenty New

Species, and a New Subgenus of Peromyscus from Mexico and Guatemala; A New Genus (Neotomodon), and Three New Species of Marine Rodents from the Mountains of Southern Mexico. Miller, J. S., Jr.: A New Rabbit from Margarita Island, Venezuela. Palmer, T. S.: Notes on the Nomenclature of the Cheiroptera.

BOTANY.

Pfeffer's Physiology of Plants.[1] — Only the first of the two volumes of Pfeffer's *Pflanzenphysiologie* has yet appeared, the second being still in preparation. So thoroughly is this book being rewritten that it is very likely that the translations of the first volume — the French translation to be issued by a Paris publisher unaided by any subvention, I believe, and the English one to be issued by the Clarendon Press of Oxford — will be out before the second volume of the German edition is ready.

The plan of the work is the same as that of the first edition, the author confining himself to pure physiology, instead of enlarging the scope of the book to include that branch of physiology, œcology, or making more than passing allusions to the applications in agriculture, brewing, medicine, and surgery, of facts discovered and elucidated by plant physiologists. The book is a handbook, not a text-book; a critical review of the contributions to plant physiology, and a statement of the facts as they appear in the light of past discoveries and present hypotheses. It is by no means a compilation, for in almost every part of the field Pfeffer has worked, or led his students to work, fruitfully. This fact lends additional value to the critical discussions of the work of other and sometimes disagreeing investigators, and to the appreciation of the difficulties in the way of making experiments, and of drawing conclusions therefrom, — an appreciation which gives deeper insight into a problem as well and lends patience to its discussion.

In estimating the value of the book, for the facts, new and old, brought together for the first time in it, account must be made in equal amount of the skill and clearness with which defects in argument, faults in conclusion, and overzeal in theorizing are pointed out.

[1] *Pflanzenphysiologie.* Ein Handbuch der Lehre vom Stoffwechsel und Kraftwechsel in der Pflanze. Von Dr. W. Pfeffer. Zweite völlig umgearbeitete Auflage. Bd. I, Stoffwechsel. Leipzig, 1897, Wilhelm Engelmann.

Whatever may be thought of the generally involved style of Pfeffer's exposition — and this has been complained of for years by his own countrymen quite as much as it has been deplored by others — nothing could be clearer and crisper than some of his critical remarks. He goes directly to the point, and states it clearly. Regarding the exposition, I believe that it, too, is clearer and simpler than in the first edition and than in many of Pfeffer's papers; but it can never be "easy reading" for any foreigner because of the detail of fact and theory into which Pfeffer goes in his treatment of every topic.

What DeBary's *Comparative Anatomy of the Vegetative Organs of the Phanerogams and Ferns* was intended to be and what it has been for plant anatomy, Pfeffer's *Handbuch* was in the first edition, and cannot fail to continue to be in the second, for plant physiology. In the survey of what has been discovered are pointed out many of the problems which remain to be solved. Thus knowledge is broadened and zeal for research is kindled and directed.

The first volume is devoted to the consideration of the subject announced by the title, namely, "Stoffwechsel," or metabolism in the broad sense. Before treating of this, however, the author presents three chapters covering nearly seventy-five pages. The first is an introductory one broadly stating the object of physiology, — "to study the manifestations of life as such, to trace these back to their nearer and further causes, and to become acquainted with these in their significance for the organism"; the second is devoted to a discussion of the cell from the morphological-physiological standpoint; the third deals with the phenomena of swelling as indicating molecular structure. The remaining five hundred and fifty pages in this volume are occupied with the subject of nutrition, — respiration (and the fermentations dependent upon the respiration of certain organisms) being considered as a part of the destruction processes concerned in the nutrition of the organism.

Within the limits of a review, any adequate treatment in detail of the contents of this volume is impossible. The student of physiology, whether he use animals or plants as the subjects of his observation, will find the book rich in facts, broadening in its masterly treatment of the conceptions to be built upon these facts, and inspiring in the high, enthusiastic, yet controlled devotion of the author to the subject to which he has so fruitfully devoted his life, and in which, as teacher and writer, he has led so many others.

George J. Peirce.

Living Plants and their Properties.[1] — These essays were read, on various occasions within the last few years, to audiences as diverse as the Linnean Society of London and "The Parlor Club, an organization devoted to literary and scientific culture, Lafayette, Indiana," or else were published in magazines, bulletins of agricultural experiment stations, etc.

The preface expresses the hope that this volume will arouse a more general interest in the phases of botany treated. The reviewer fears that the general reader will be discouraged by two qualities common to the majority of the essays. First, the number of undefined technical terms, familiar enough to botanists, but rather appalling to others, and of Latin generic names, unaccompanied by any suggestion as to the family of the plants spoken of, is unfortunately large. Second, the absence of definite conclusions concisely summed up at the end of discussions.

If so much adverse criticism may be brought against the book, much may, on the other hand, be said in its favor. The authors are professional botanists, know what they are talking about, and have the faculty of saying things attractively. More than this, in treating physiological subjects and problems, they consistently indicate the fundamental identity of the functions of animals and plants, and show that this is due to their having the same living substance as the physical basis of their existence. The elucidation and the understanding of any function of a plant is greatly facilitated by a comparison with the much more familiar expression of the same function in man or in some other animal; but it does not necessarily follow, as is well stated in the essay on the special senses of plants, that all the advantage is on one side. When animal and plant physiologists realize that they have common problems which they can best work out together, they will be as helpful to each other as the animal and plant cytologists have been and still are; and together they will be more effective in advancing knowledge than when the one cleaves only to muscles and the other to roots.

GEORGE J. PEIRCE.

A New Botanical Journal. — The following preliminary announcement of a new periodical has just been received:

The New England Botanical Club is considering the publication of a monthly journal, to begin January 1, 1899. It is to be an octavo of about

[1] *Living Plants and their Properties.* A collection of essays by Joseph Charles Arthur, Sc.D., and Daniel Trembly MacDougal, Ph.D. New York, Baker and Taylor, 8vo, 242 pp., 30 pls., and figures.

sixteen pages each issue, and illustrated by full-page plates. It will deal primarily with the flora of New England, especial attention being given to rare plants, extended ranges of distribution, and newly introduced, as well as newly described, species. Articles have been already promised by many of the foremost New England botanists, both professional and amateur, and while a high standard will be maintained in the matter of scientific accuracy, needless technicality of style will be carefully avoided, so that any person who can use *Gray's Manual* will be able to read the proposed journal with pleasure and interest. Not only the flowering plants and ferns, but fleshy fungi and other cryptogams will receive attention. The price of the journal has been fixed at one dollar per annum.

While more than two hundred subscriptions have already been promised in advance, the Club does not feel warranted in proceeding with its plan of publication unless assured of much further support. All persons interested in botany and in the maintenance of such a journal in New England are earnestly solicited to send at once subscriptions for at least one year (which, however, need not be paid before January 15, 1899) to

EDWARD L. RAND,
Corresponding Secretary N. E. Botanical Club,
740 Exchange Building, Boston, Mass.

It may seem remarkable that with the many existing botanical periodicals it should be thought necessary to establish new ones, but it is clear that the journal here contemplated will be devoted to a field not at present cultivated by any existing periodical, namely, the local flora of New England. The journal will, doubtless, be largely systematic, and will attempt to do for New England what such periodicals as the *Deutsche Botanische Monatschrift*, *Œsterreichische Botanische Zeitschrift*, etc., have long done so admirably for the European regions they cover. In the present enthusiasm for histology, cytology, œcology, and vegetable physiology, it is not uncommon for a botanical student to plunge into structural problems of extreme technicality without adequate systematic training to give him a proper sense of proportion in his work. To know well the different groups of some one local flora is not only in itself a great source of pleasure, but is a most excellent preparation for subsequent histological or physiological study. There is, furthermore, a great deal still to do upon the systematic botany of New England. Some of the most common species of plants are proving themselves to be puzzling aggregates of closely related forms, each of which must be studied separately before its proper status and exact distribution can be learned. The flora is constantly changing, through the extermination

of species in certain localities, and the still more common introduction of plants of the Old World. There are many reasons why these changes should be carefully watched and duly recorded. Papers dealing with these matters, however, are chiefly of local interest, and lose much of their instructive power and significance if published in a journal remote from the field they cover. It is, doubtless, with a clear perception of these conditions that the New England Botanical Club proposes to issue a small but convenient medium for such communications regarding the flora of New England. The Club was founded in December, 1895, and now contains thirty-five resident members (those living within twenty-five miles of Boston), and as many non-resident members. Its annually elected presidents have been Prof. W. G. Farlow, Mr. N. T. Kidder, and Prof. G. L. Goodale. The herbarium of the Club is situated in the Botanical Museum at Cambridge, Mass. It has been of rapid growth, and is likely to become the most complete local collection of New England plants. The earnest and scholarly *personnel* of the New England Botanical Club is the best guarantee for the success of the proposed journal.

B. L. R.

Garden-Making.[1] — While horticulture is an art rather than a science, its methods and results have such a manifold bearing upon plant life that a good work on gardening must always have a great interest for botanists. The 400-page octavo now at hand is neat, carefully planned, and copiously illustrated. It is true, in this age of handy manuals, these may not seem very exceptional qualities, but Professor Bailey's book has still more to recommend it. It comprises the result of much experience, is simple and practical in its suggestions, and, above all, is written in a style which is animated and really entertaining. Suggestive works on horticulture are not rare; that is, books which are either repositories of carefully stated facts or books which with less critical presentation of facts have a pleasing style, but a book which combines a wealth of accurate and practical information with a clear, vivacious, and at times even humorous style is truly exceptional.

To many people a garden is a source of more discouragement and vexation than of pleasure. To such persons Professor Bailey's charmingly facetious introduction must come as a cheering philosophy, renewing interest and inspiring courage. It runs: "Every family can

[1] By L. H. Bailey, aided by L. R. Taft, F. A. Waugh, and E. Walker. Published by the Macmillan Co., New York, 1898. $1.00.

have a garden. If there is not a foot of land, there are porches or windows. Wherever there is sunlight, plants may be made to grow; and one plant in a tin can may be a more helpful and inspiring garden to some mind than a whole acre of lawn and flowers may be to another. The satisfaction of a garden does not depend upon the area, nor, happily, upon the cost or rarity of the plants. It depends upon the temper of the person. One must first seek to love plants and nature, and then to cultivate that happy peace of mind which is satisfied with little. He will be happier if he has no rigid and arbitrary ideals, for gardens are coquettish, particularly with a novice. If plants grow and thrive, he should be happy; and if the plants which thrive chance not to be the ones which he planted, they are plants, nevertheless, and nature is satisfied with them. We are apt to covet the things which we cannot have; but we are happier when we love the things which grow because they must. A patch of lusty pigweeds, growing and crowding in luxuriant *abandon*, may be a better and more worthy object of affection than a bed of coleuses in which every spark of life and spirit and individuality has been sheared out and suppressed. The man who worries morning and night about the dandelions in the lawn will find great relief in loving the dandelions. . . . If I were to write a motto over the gate of a garden, I should choose the remark which Socrates made as he saw the luxuries in the market: 'How much there is in the world that I do not want!' . . . I expect, then, that every person who reads this book will make a garden, or will try to make one; but if only tares grow where roses are desired, I must remind the reader that at the outset I advised pigweeds. The book, therefore, will suit everybody, — the experienced gardener, because it will echo of what he already knows; and the novice, because it will apply as well to a garden of burdocks as of onions."

After this cheery introduction follows a host of practical suggestions regarding the preparation of soil, selection and use of implements, choice of sites, arrangement of borders, shrubbery, and paths, times of planting, qualities and relative desirability of different species of plants, protection of plants from insects and parasites, desirable forms of hothouses, etc. Especially noteworthy among the many sketchy but very telling illustrations are the "informal flower border" (drawn by Mr. F. Schuyler Mathews) and the contrasting pictures of "a house" and "a home." The whole work is a most forcible argument for informality in horticulture.

In connection with *Garden-Making* may be mentioned another

similar and still more recent manual by the same author, and called the *Pruning Book*. It is also one of Professor Bailey's "Garden-craft series," and, like its companion volumes, is full of well-told and practical information upon its subject, which, of course, primarily interests those engaged in the care of ornamental trees, shrubbery, orchards, or vineyards.

B. L. R.

Sulphur Bacteria. — Prof. Manabu Miyoshi gives an interesting preliminary account[1] of some of the organisms found in the hot sulphur springs of Japan. The first part of the paper consists mostly of field observations on a long scythe-shaped, peritrichiate, colorless, gelatinous bacterium which grows in masses in the hot springs of Yumoto and is covered with sulphur. The second part consists of an account of species of cophromatium and various other one-flagellate purple or rose-colored water organisms which frequently occur in patches in pools and swamps in the vicinity of the sulphur springs.

The scythe-shaped peritrichiate form is mostly $20 \times 1.4\ \mu$ in size, but other much smaller curved rods occur. In places, also, species of Beggiatoa and Thiothrix may be found. The gelatinous masses grow only near the surface of the water in rapid-flowing hot streams charged with sulphide of hydrogen. They do not occur in quiet water, or in the depths, or in water cooler than 51° C. They are able to grow in very hot water, having been found in rapid streams, the temperature of which was 68° to 69.8° C. (154.4° to 157.6° F.). They have only been found in water containing sulphide of hydrogen, and this gas is believed to be necessary to their growth. Free access of oxygen is necessary to bring about the deposit of the sulphur crystals. The organisms will grow in closed conduits, but no macroscopically visible sulphur is deposited on them. When such masses were removed and put into open running water there was an immediate deposit of sulphur, and in an hour they became indistinguishable from the surrounding flocks. The sulphur deposit, which is very copious, and always, or at least usually, on the outside of the rods, covers even the thinnest threads, and appears to be in some way connected with specific properties of the gelatinous covering of the organisms. No deposits of sulphur at all comparable could be obtained by putting into the water fine linen threads covered with starch jelly, half coagulated albumen, concentrated gela-

[1] M. Miyoshi, Studien über Schwefelrasenbildung und die Schwefelbacterien der Thermen von Yumoto bei Nikko, *Journ. College Sci.*, Imp. Univ., Tōkyō, vol. x, Pt. ii, pp. 143–173, 1897.

tin or thick glue. Under favorable conditions this growth is extremely abundant and very conspicuous, filling the streams and pools with white or yellowish-white, thready, flocculent, firmly anchored, streaming masses, which are usually 3 to 5 cm. long, but which in small rapid brooks sometimes reach a length of 20 cm. The water of Yumoto is only very feebly acid, but contains a large amount of sulphide of hydrogen (about 0.04 grams per liter), and also considerable calcium bicarbonate (0.0624 grams per liter). Professor Miyoshi suggests that these organisms, the protoplasm of which must be endowed with great energy owing to the temperature at which it grows, oxidize the H_2S *directly* to H_2SO_4, which acid does not interfere with the life of the bacteria because it is quickly neutralized by the alkaline bicarbonate of the running water. A discussion of the morphology and physiology of these organisms is reserved for a subsequent paper, no opinion being ventured as to whether the gelatinous masses consist of one or of several species.

In the second part, the chemotropism of *Chromatium weissii* is discussed, and some new genera and species of the red sulphur bacteria are established. The three new genera are Thioderma, Thiosphærion, and Thiosphæra. Using Pfeffer's capillary method he obtained among others the following results with *Chromatium weissii.* It was powerfully attracted by the following substances: water containing various quantities of sulphide of hydrogen, 0.3% potassium nitrate, 0.3% ammonium nitrate, 0.3% ammonium phosphate, 0.5% ammonium tartrate, 0.3% potassium sodium tartrate, 0.3% monopotassium phosphate (neutralized by sodium carbonate). It was feebly attracted by 0.5% cane sugar, 0.5% grape sugar, 0.5% milk sugar, 0.5% asparagin. It was nearly indifferent to 0.5% glycerine, 0.3% magnesium sulphate, 0.3% ammonium chloride. It was strongly repelled by 0.5% malic acid. The organism also reacts to contact irritation. The temperature of the water in which these red bacteria grew was 23° to 35° C. An attractive lithographic plate accompanies the paper.

ERWIN F. SMITH.

Ripening of Cheese. — Persons who are fond of Roquefort, Camembert, and other piquant cheeses will be surprised to learn that fully one-half of the bulk of such cheeses, and often much more, consists of the mycelium and spores of fungi. These are not accidental impurities but necessary constituents, by means of which the various cheeses are ripened, and to which they owe their peculiar flavors. In reality, those who eat these appetizing cheeses consume

more fungus than cheese. The author of these statements is Dr. Olav Johan-Olsen,[1] the well-known mycologist, who will be remembered as joint author with Drs. Brefeld and Istvánffy of two large volumes on basidiomycetous fungi (Hefte vii and viii of Brefeld's *Untersuchungen*). For some years Dr. Johan-Olsen has been in charge of a royal Norwegian laboratory for the study of fermentations, and has had unlimited facilities for experimental cheese-making, and also good opportunities for studying the cheese industry in France and other parts of Europe. He has spent ten years in his efforts to discover exactly how to make cheeses of special brands, has used up more than 110,000 liters of milk, and has made thousands of microscopic examinations and special cultures, more than 500 different organisms having been isolated from a single variety of cheese. He now declares that his work has passed out of the experimental stage, and that he has discovered exactly how to make (by adding pure cultures of specified organisms to sterile or nearly sterile milk) well-known cheeses on a commercial scale. For example, one of the finest Norwegian cheeses is known as Gammelost. This cheese has a peculiar flavor, suggestive of apples, citron, and Camembert cheese, and always brings a good price. It is made by peasants in huts in the mountains, and there are so many uncertainties connected with its rule-of-thumb manufacture that only 10% of the product is first-class. By means of his pure-culture inoculations Dr. Johan-Olsen is now able to make this cheese on a large scale with a high degree of certainty, 90% of the product being first-class, without bad odor, with very fine flavor, and with better appearance and better keeping qualities than the same cheese as ordinarily made. No less than 15,000 kilos of this scientifically ripened cheese was produced last year. For a long time Dr. Johan-Olsen's experiments were barren of practical results, owing to his belief that the ripening of the cheese was due to bacteria. The abandonment of this hypothesis was followed by the discovery that the ripening and peculiar flavor of the most celebrated cheeses are due to the presence of fungi, and, what is still more interesting, to the joint action of several different sorts, one alone not being able to bring about the desired result. Until this symbiotic relationship was discovered he declares that hundreds and thousands of his cheese experiments miscarried, so that many of the cheeses had to be thrown away. In

[1] O. Johan-Olsen, Die bei der Käsereifung wirksamen Pilze, *Centralb. f. Bakt., Parasitenkunde, u. Infektionskr.*, Abt. ii, Bd. iv, No. 5, March 5, 1898, pp. 161–169.

case of the Gammelost the ripening and flavoring are accomplished by adding to the sour, coagulated skimmed milk two fungi, *viz.*, a Penicillium and a Mucor. The blue mold used is not *P. glaucum*, which always spoils the cheese when it gets into it, but a hitherto unrecognized species, *P. aromaticum*. In the green cheese, which is said to taste like sour horn, dead yeast and lactic acid organisms prevail; in the ripe cheese, which has an entirely different structure and appearance, Mucor and Penicillium are very abundant, Mucor being most abundant and exerting the predominant influence if the cheeses are ripened at high temperatures, and Penicillium if they are ripened at moderate temperatures.

We are not told what fungi should be used to ripen and flavor Gorgonzola, Roquefort, Camembert, and Norwegian cheese (goat cheese), but are given to understand that these problems have been solved, and also that he will soon be in condition to give exact directions for making Stilton, Gouda, Eidam, Cheddar, Emmetthaler, and other cheeses. The paper from which these statements have been taken is illustrated by six lithographic plates showing Gammelost and the fungi required to ripen and flavor it. ERWIN F. SMITH.

A New Check-List of North American Plants.[1] — At the Buffalo meeting of the American Association the botanists interested in the Rochester nomenclature decided to prepare a reform check-list of the higher plants of North America. This list, except in its greater territorial scope, was to be much like the one already issued for northeastern North America. The work, we believe, was to be assigned so far as possible to specialists, each of whom should treat only such groups as were most familiar to him. It is needless to say that many botanists have grave doubts as to the value of such a list. They see clearly that the Rochester nomenclature, instead of being an ideal system, has serious defects which will, as they believe, preclude its ultimate success. However, if such a list was to be prepared at all, there is reason to commend the coöperative plan adopted. The consistent application of any new principle of nomenclature to the flora of such a vast area is a matter of great and obvious difficulty, and it was the hope of the conservatives as well as the reformers that the work, if undertaken, might be carried out with caution and scholarly methods. For these reasons it is a matter for general regret that the proposed critical list has been anticipated

[1] Heller, A. A. *Catalogue of North American Plants North of Mexico, Exclusive of the Lower Cryptogams.* Minneapolis, March 10, 1898.

by a crude and hasty compilation. Mr. Heller has undoubtedly prepared and issued his list with sincere conviction that he was thereby advancing the cause of the Rochester nomenclature and meeting a need of American botanists.. But in these days of critical work and high bibliographical ideals, when references are carefully verified and proofs repeatedly read, the appearance of a work containing so many glaring errors can scarcely commend any system.

A slight examination of the list shows such "first correct combinations" as *Silene cucubalus*, *Arenaria sajanensis*, and *Anoda lavateroides* on equal footing with Rochester names, some of which are their exact synonyms. Names indorsed by the *Illustrated Flora* appear on the same pages with others, such as Cheiranthus (for Erysimum), which are quite opposed to the usage of Messrs. Britton and Brown. All the Cerastiums are appended to Arenaria. Misprints abound. Some good species are omitted. Genera are subjected to extreme subdivision and many obvious varieties are ranked as species. In some cases the same species, such as *Montia sarmentosa* and *M. saxosa*, appear coördinately under different genera. *Trifolium gracilentum* and its variety are repeated under different numbers. No care has been taken to give consistent and uniform abbreviations of authorities. Thus on a single page of the Cactaceæ the eye meets "Engelm. & Bigel.," "E. & B." "Engel. & Bigel.," "Eng. & Big.," "Engelm. & Big.," and "Englm." Finally, a considerable number of pure synonyms are rehabilitated.

After wandering about in this nomenclatorial maze, the bewildered reader, in hope of finding some key to it, turns to Mr. Heller's preface, there to learn that during the last few years "a more stable system of nomenclature has been introduced." Is this irony? Surely, if the author knew of such a system, he might have divulged it for the good of his fellow-botanists, and not have jumbled up "Kew rule" names, on the one hand, with Brittonian and Greenean names, on the other, to say nothing of a liberal admixture of the merest synonyms.

No genus has been more discussed by the reformers than the one which they call Tissa. The group has been revised by one of their number and largely augmented by another. The generic name Tissa, which meets with little favor by the rest of the world, has in a way become the shibboleth of the Rochester reformers. Let us see how Mr. Heller treats this much-emphasized genus. He recognizes sixteen species and varieties. Of these *T. clevelandi* and *T. leucantha* have incorrect parenthetical authorities; *T. clevelandi*

Greene and *T. villosa* Britton are exact synonyms, founded upon the same plants of the Pacific slope; *T. macrotheca*, var. *scariosa*, and *T. pallida* are also perfect and confessed synonyms; the recent *T. gracilis* is identical with the much older *Spergularia plattensis* of South America; *T. salsuginea* Bunge is an impossible combination as the last of Bunge's many papers was published before the resurrection of Tissa, while *Spergularia salsuginea* (Bunge) Fenzl in its American use is an exact synonym of *T. diandra*. Thus, of Mr. Heller's sixteen species and varieties about half are either repeated under some obvious synonym or are adorned with incorrect authorities. These are not differences due to divergent botanical opinion. They are clearly errors of careless compilation, all of which could have been easily avoided by slight study of the recent monographs. Surely, this is not the best that our reformers can do with their pet genus after more than five years of unprecedented activity.

B. L. R.

A Review of Canadian Botany.[1] — The second portion of Professor Penhallow's admirable historical sketch, now before us, traces botanical activity in Canada from 1800 to 1895. The first few pages describe the Canadian work of the younger Michaux, Pursh, F. A. Holmes, Titus Smith, Goldie, the Hookers, La Pylaie, Brunet, Provancier, the late George Lawson, Sir William Dawson, and some others. Attention is then directed to the botanical gardens, societies, and collections of Canada, to the results of the Natural History Survey under Professor Macoun, and to the facilities for botanical work in the leading educational institutions of the country. The larger and by far the most valuable part of the paper, however, is an excellent bibliography of Canadian botany during the period covered. This list contains nearly five hundred titles and shows exceptional care and attention to detail.

B. L. R.

Coastal and Plain Flora of Yucatan.[2] — Dr. Millspaugh's third important paper upon the flora of Yucatan is an annotated list of plants collected by Dr. Arthur Schott in 1864–66, by Mr. Whitmer Stone in 1890, and by Dr. George F. Gaumer in 1895–96, together with some notes and new species by Professor Radlkofer and Dr. Loesener. This catalogue enumerates more than three hundred species and varieties not hitherto recorded in the flora of this poorly known territory. No one who has not had some experience in

[1] Penhallow, D. P. *Trans. Roy. Soc. Canad.*, ser. ii, vol. iii, sec. 4, pp. 3–56.

[2] Millspaugh, C. F. *Publ. Field. Columb. Mus.*, No. 25, issued January, 1898.

the scattered literature of Mexican botany and the great difficulty of identifying tropical plants is likely to appreciate the patience and perseverance required to prepare a list of this kind. Until Dr. Millspaugh turned his attention to Yucatan, it was botanically one of the least-known parts of our continent. Both from the character of its inhabitants and the perilous nature of its climate the region has always been especially difficult to explore. The exceptional energy with which Dr. Millspaugh has overcome these difficulties and collated in such a convenient form the results of his personal observations and those of others merits much praise. B. L. R.

Oudemans's Fungi of the Netherlands.[1] — In this large work, the second volume of which appeared last year, we have one of the most interesting and carefully elaborated fungus floras which has yet appeared. It represents the ripe life work of the well-known mycologist Dr. Oudemans, and both in its preparation and publication great pains has been taken to make an attractive and useful book. Were it simply a local flora, there would be no need of mentioning it here. It is much more than this for several reasons: (1) many of the species described in it are of wide distribution; (2) the generic and specific characters have been worked over independently, apparently with great care, and therefore are very useful for comparison with those of Saccardo, Winter, Schroeter, and other authors; (3) considerable attention has also been given to bibliography and synonomy. These two volumes deserve a place in the library of every critical student of the fungi, and it is to be hoped that the life and strength of the author may be spared to complete the work by the addition of a third volume on the *fungi imperfecti.* The volumes are printed in clear type on good paper and wholly in French. Each volume is indexed. Volume ii also contains a host index and fourteen plates of figures illustrating the genera of the Pyrenomycetes. The latter are a second edition of Saccardo's "Genera Pyrenomycetum schematice delineata" with the figures redrawn and corrected where necessary. ERWIN F. SMITH.

[1] Oudemans, C. A. J. A. *Révision des Champignons des Pays-Bas.* Amsterdam, Johannes Müller. Tome i, Hyménomycètes, Gastéromycètes, et Hypodermées. 8vo, 638 pp. 1892. Tome ii, Phycomycètes, Pyrénomycètes. 8vo, xvi + 518 pp., tab. xiv. 1897.

PALEONTOLOGY.

Spencerites.[1] — This genus is founded upon the *Lepidostrobus insignis* and *Lepidodendron spenceri* of Williamson, whose material consisted of cones with their detached peduncles, but no vegetative parts. The specimens were derived from the coal measures of Lancashire and Yorkshire, and were first described by Williamson in 1878.

A review of this material in conjunction with additional specimens from different sources, convinces Dr. Scott that the characters presented by the cones are such as to demand the institution of a new genus under the name of Spencerites. To this are assigned Williamson's *Lepidodendron spenceri*, from which the generic name is taken, and *Lepidostrobus insignis*, under the name of *S. insignis*. The essential features of this species are found in the course of the leaf trace bundles; in the peltate form of the sporophylls which consist of a short, cylindrical pedicel expanding into a relatively large lamina; the approximately spherical sporangia which are quite free from the pedicel, but attached by a narrow base to the upper surface of the lamina where it begins to expand, and in the characteristics of the spores which are intermediate between the microspores and macrospores of Lepidostrobus and are provided with a hollow wing formed from the dilated cuticle about the equator.

Spencerites majusculus, a new species, is a large plant with larger cones; the sporophylls are more numerous, but the spores are much smaller, form quadrants of a sphere, and have narrow wings along their three angles.

The genus differs from Lepidostrobus chiefly on account of the different mode of insertion of the sporangia, the structure of the sporangial wall and of the spaces, and also the whole habit of the cone.

Cheirostrobus.[2] — From the well-known Calciferous Sandstone Series at Pettycur, on the Firth of Forth, there has been obtained an entirely new type of cone which Dr. Scott describes under the name of *Cheirostrobus pettycurensis*, thus adding to the eight distinct types

[1] Scott, D. H. On the Structure and Affinities of Fossil Plants from the Palæozoic Rocks, *Phil. Trans. R. Soc.*, Ser. B, 189 (1897), 83–106.

[2] Scott, D. H. On Cheirostrobus, a New Type of Fossil Cone from the Lower Carboniferous Strata (Calciferous Sandstone Series), *Phil. Trans. R. Soc.*, Ser. B, 189 (1897), 1–34.

of cones already known as occurring in the Palæozoic rocks. As found in a calcified form, the cone, somewhat flattened, measures about 5 cm. in its greatest, and from 2 to 2.3 cm. in its shortest diameter. It consists of a cylindrical axis bearing numerous compressed sporophylls arranged in crowded, many membered verticils. Each sporophyll is divided nearly to its base into an inferior and a superior lobe; the lobes are palmately divided into segments, of which half are fertile and half are sterile, each segment consisting of an elongated stalk bearing a terminal lamina. The large sporangia, of which there are usually four on each sporangiophore, are attached by their ends remote from the axis, to the peltate laminæ of the sporangiophores, and contain numerous spores. These latter are about .065 mm. in diameter.

While there are certain features which suggest comparison with certain Gymnosperms, Dr. Scott concludes that in reality it belongs to the Sphenophylleæ, presenting, in certain respects, a remarkable agreement with such forms as *Sphenophyllum dawsoni* and *S. Cuneifolium*. From the additional light which this plant throws upon the allied genus, the Sphenophyllineæ are regarded as representing a generalized type combining many of the features of Equisetineæ and Lycopodineæ, and indicating the common origin of these two series.

Lepidophloios.[1] — Recent studies of material collected during the past fifty years enable the author to separate two species under the names of *Lepidophloios acadianus* and *L. cliftonensis*. The genus is represented by large and dichotomously branching trees bearing very long and linear leaves. The usually stout branches give rise to slender branchlets bearing spirally arranged and stalked cones. The persistent leaf bases give to the stem a rugged and scaly appearance, but as these characters are removed by decay or other causes, there often remains only a smooth surface bearing mere traces of the original leaves, hence much of the material properly belonging to this genus has been described under the name of Halonia and Bothrodendron.

The internal structure conforms to the Sigillarian type. The author shows that the genus is clearly related to Lepidodendron, with which it may readily be confounded, and summarizes his views as to the general relations of this and allied genera in the statement

[1] Dawson, Sir J. W. On the Genus Lepidophloios as Illustrated by Specimens from the Coal Formation of Nova Scotia and New Brunswick, C. M. G., *Trans. R. Soc. Can.*, Second Ser., III (1897), iv, 57.

that the "Sigillariæ are to be regarded as a central generalized group, from which, in regard to structure and affinities, various genera radiate towards Cycads and Conifers on the one hand and Lycopods and Equisetums on the other." D. P. P.

PETROGRAPHY.

The Classification of Igneous Rocks. — Messrs. Iddings[1] and Cross[2] have contributed two interesting articles on that most attractive of all petrographical problems, the classification and naming of igneous rocks. Although attacking the subject from entirely different standpoints, both authors nevertheless reach approximately the same conclusions. Cross declares that "the impossibility of setting up an all-embracing natural classification of igneous rocks is not due to ignorance. It comes from the nature of the rock. The more we know the less shall we be able to include all relations in one classification." Iddings states "that a systematic classification of all kinds of igneous rocks cannot be put on the same basis as a philosophical treatise of the subject-matter of petrology, which takes cognizance not only of the material character of rocks, but also of the laws governing their production, eruption, mode of occurrence, and solidification, as well as their subsequent alteration."

Iddings discusses critically, with the aid of diagrams, the composition of igneous rocks, as indicated by nine hundred and fifty-eight analyses, and shows that no chemical classification will exhibit the true genetic relationships existing between different rock types, and that a mineralogical classification is likewise useless for this purpose. It is, therefore, of no avail to attempt a genetic classification of rocks if it is desired by the classification to group together those rocks that have like characters, in order that they may receive a common name. The present classification, and the nomenclature to which it has given rise, are both unsatisfactory. The need for a new nomenclature is especially pressing, and yet "the condition of our knowledge at present is scarcely such as to warrant the immediate attempt to create a systematic nomenclature."

The point of Cross's paper is to the effect that the present unsatisfactory condition of rock classification is due to the fact that too many

[1] Iddings, J. P. On Rock Classification, *Journ. of Geol.*, vol. vi, p. 91.

[2] Cross, W. The Geological *versus* the Petrographical Classification of Igneous Rocks, *Journ. of Geol.*, vol. vi, p. 79.

relationships are expected to be shown in it. He believes "that no great progress in systematic petrography is possible until a more rational view of the relationship of that science to geology prevails among its devotees." The rock, in petrography, is a unit of material; while in geology it is a unit of form or mass. The geological rock is the subject of study in *petrology*. The classification of rocks in *petrography* should be a classification based on facts and not on theories; it should be based on the properties of the rocks themselves, and upon their relationships to one another and to the earth. No natural classification of rocks is possible, because of the nature of these bodies. "The systematic classification of rocks, according to which their specific names are applied, must be based on their properties as objects, together with only such geological criteria as may be found adaptable, to the end that the system may be uniform, stable, and as natural as possible." The author examines critically the accepted scheme of classification as now used, and shows that it is illogical, being based primarily on geological criteria that are largely theoretical. He objects also to the founding of the classification upon such hypothetical factors as those embraced in the theory of magmatic differentiation. On the other hand, "the material properties of igneous rocks afford ample criteria for establishing a systematic classification. . . . Since the geological factors of age, or of form, or place of occurrence, are not directly causes of the properties used in classification, they cannot be applied to produce coördinate groups."

Leucite Rocks from Montana. — In another paper Cross[1] reports the existence of a most interesting series of leucite rocks at the Leucite Hills and Pilot Butte, Wyoming. Some of these rocks have already been described by Zirkel, Emmons, and Kemp, but none of these geologists had learned of the great variety of types in the region. The principal area of leucite rocks is a mesa whose top consists of a surface flow of porous and massive rock material, the latter of which corresponds to Zirkel's leucitite, while the vesicular rock is a sanidine-leucite aggregate. The massive rock is redescribed by Cross as consisting of phlogopite crystals in a groundmass made up of leucite crystals and anhedra, separated from one another by pale green or colorless microlites of diopside, imbedded in a very siliceous glass. This rock the author calls *wyomingite*.

The principal rock of the Leucite Hills is the sanidine-leucite

[1] *Amer. Journ. Sci.*, vol. iv, p. 115, 1897.

aggregate referred to above. In addition to the two minerals mentioned, it contains also phlogopite, amphibole, and diopside. The phlogopite is in phenocrysts. The sanidine and the leucite are usually grouped in separate patches, the former in aggregates of stout, square prisms, associated with ophitic amphibole and with diopside, and the leucite in aggregates of minute anhedra, some of which are enclosed in amphibole prisms. The sanidine is filled with inclusions of diopside needles. The rock is called *orendite.* The amphibole of the orendite possesses very peculiar properties. While having a prismatic cleavage angle of 124°, its extinction appears always to be parallel to the c axis. Its pleochroism is $\mathfrak{a} = a$, pale yellow; $\mathfrak{b} = b$, red; $\mathfrak{c} = c$, bright yellow, and its axial figure is almost that of a uniaxial mineral.

The rock of Pilot Butte, a mesa separated from the Leucite Hills by a valley, is composed of colorless diopside, phlogopite, and, probably, perofskite, in a brown glassy base of the composition of leucite. This rock, which is probably a portion of a volcanic flow, is called *madupite.* The phlogopite of the madupite differs from that of the orendite in that it occurs as roundish grains filled with diopside microlites and perofskite grains. The cleavage is not as well marked as is usually the case in micas, but the optical properties are those of phlogopite.

The chemical composition of the three types of rocks is represented by the analyses following:

	Wyomingite	*Orendite*	*Madupite*
SiO_2	= 53.70	54.08	42.65
TiO_2	= 1.92	2.08	1.64
Al_2O_3	= 11.16	9.49	9.14
Fe_2O_3	= 3.10	3.19	5.13
FeO	= 1.21	1.03	1.07
CaO	= 3.46	3.55	12.36
BaO	= .62	.67	.89
MgO	= 6.44	6.74	10.89
K_2O	= 11.16	11.76	7.99
Na_2O	= 1.67	1.39	.90
H_2O at 110°	= .80	.79	2.04
H_2O above 110°	= 2.61	2.71	2.18
P_2O_5	= 1.75	1.35	1.52
Other constit.	= .80	1.14	1.71
Totals	100.40	99.97	100.11

The constituents included among the "other constituents" are ZrO_2, Ce_2O_3, Di_2O_3, Cr_2O_3, MnO, SrO, Li_2O, SO_3, Cl, Fl, and CO_2. The totals corrected for Fl are 100.21, 99.76, and 99.91.

The author points out the practical identity in the composition of the wyomingite and orendite, and concludes from this identity "that chemical composition of a magma does not alone determine whether leucite or sanidine shall be formed, but that this is controlled by conditions of consolidation."

A reclassification of leucite rocks is proposed, based on the quantitative importance of the leucite in them. The term leucitite is reserved for rocks in which leucite is the predominant component. Wyomingite and its granular equivalent are rocks in which leucite is of approximately equal importance with the ferro-magnesian-lime silicates. Orendite contains sanidine and leucite in about equal quantities. Both of these rocks are rich in silica. In madupite the heavy silicates predominate, leucite being in subordinate quantity. Its magma is low in silica.

Inclusions in the wyomingite and the orendite have been subjected to considerable contact action, the feldspars in the inclusions having suffered more than the bisilicates.

SCIENTIFIC NEWS.

THE collections of the late Professor Cope, which were bequeathed to the biological department of the University of Pennsylvania, have been turned over to the university. The most valuable of these are the books, the library containing many sets of journals, as well as a very large collection of monographs, separata, and books of reference. Next in order came the collection of skeletons of recent vertebrates, the nucleus of which was the collection of fish skeletons made by the late Professor Hyrtl, of Vienna, and purchased by Professor Cope over twenty years ago. These formed the basis of the work by Professor Cope on the classification of fishes. Besides, there were very considerable collections of shells and of minerals. The university has also received botanical collections from Biltmore, N. C., and from Prof. J. T. Rothrock.

The Washington Academy of Sciences is now organized, as a result of the affiliation of the various scientific organizations in that city. The officers for the present year are: president, J. R. Eastman; vice-presidents, J. W. Powell, L. O. Howard, H. N. Stokes, W. H. Ashmead, A. Graham Bell, Chas. D. Walcott, I. C. Busey, and F. H. Bigelow; secretary, G. K. Gilbert; treasurer, B. R. Green; managers, Marcus Baker, H. S. Pritchett, Geo. M. Sternberg, F. W. Clarke, C. Hart Merriam, Lester F. Ward, Frank Baker, and Carroll D. Wright.

Professor MacMahon, of Cornell University, has been elected general secretary of the American Association for the Advancement of Sciences, in place of the late Professor Kellicott.

The University of Pennsylvania will reopen its summer laboratory at Sea Island City, N. J., this summer. Dr. Milton Greenman will be in charge. It was established some eight years ago, but has been closed for the past five years.

On June 28–30, there will be conferences of science teachers in connection with the Omaha exposition; Prof. Conway Macmillan, of the University of Minnesota, will take charge of the botanical conference; Prof. Henry B. Ward, of the University of Nebraska, of the zoölogical conference; and a selection is yet to be made for the geological conference.

Is there anything in connection with science more exasperating than the attitude of the present city government of New York? The discharge of Dr. T. H. Bean from the directorship of the recently established aquarium, and his replacement by Col. James E. Jones, is one of the worst cases of the doctrine "to the victors belong the spoils" that has yet been brought to our notice.

Yale University desires funds for a building for physiological chemistry and for the completion of the Peabody Museum of Natural History.

The Smithsonian Institution has just issued a new edition of the catalogue of publications, issued under its auspices, with the prices at which those now in stock can be had. The total number of titles enumerated amounts to over 1000.

Prof. J. S. Kingsley goes with a party of Tufts College students to South Harpswell, Maine, for the summer. A house has been hired, and will be equipped as a laboratory.

The University of Berlin has conferred the degree of Doctor of Laws upon Prof. J. Victor Carus, the well-known editor of the *Zoologischer Anzeiger.*

Profs. Alphonse Milne Edwards and Raphael Blanchard will attend the International Zoölogical Congress, at Cambridge, as delegates from the University of Paris.

The University of Chicago has under consideration the establishment of a series of fellowships of the annual value of $750, to be granted to students who have received the degree of Doctor of Philosophy from that institution. These fellows are to devote their time solely to investigation. The fellowships are to be awarded annually, but incumbents will be eligible to reëlection for a period not to exceed five years. Such a series of fellowships will be a great stimulus to research.

Prof. Friedrich Körnicke has resigned the chair of botany at the Poppelsdorf Agricultural School, connected with the University of Bonn.

Recent appointments: Prof. W. P. Blake, of Tucson, geologist of Arizona. — Mr. E. G. Coghill, of Brown University, assistant in biology in the University of New Mexico. — Mr. F. S. Maltby, of Johns Hopkins University, assistant in the bacteriological laboratory of the

University of New Mexico. — Dr. F. Noll, professor of botany in the Poppelsdorf Agricultural School at Bonn. — Surgeon Major David Prain, superintendent of the Botanical Gardens at Calcutta. — Dr. Heinrich Ries, instructor in economic geology in Cornell University. — Prof. John Weinzetl, of Madison, Wisconsin, director of the bacteriological laboratory and associate professor of biology in the University of New Mexico.

Recent deaths: Alfred Allen, at Bath, England, formerly editor of the *Journal of Microscopy and Natural Science*, March 24, aged 64. — Melville Atwood, geologist and metallurgist, at Berkeley, California, April 25, in his 88th year. — John Shearson Hyland, petrologist, on the west coast of Africa, April 19, aged 32. — Dr. F. Sandberger, professor of mineralogy in the University of Würzburg, aged 72.

PUBLICATIONS RECEIVED.

Annales de la Société Royale Malacologique de Belgique. Tome xxviii (Ann. 1893); tome xxix (Ann. 1894), 1896; tome xxxi (Ann. 1896), 1896. — *Bulletin of the Johns Hopkins Hospital.* Vol. ix, No. 86, May. — *The Forester.* Vol. iv, No. 5, May. — *Geographical Magazine.* Vol. xi, No. 5, May. — *The Industrialist.* Vol. xxiv, No. 6. Manhattan, Kansas, June, 1898. — *Jenaische Zeitschrift für Naturwissenschaft.* Bd. xxxii, Hefte 1, 2. 1898. — *Journal of the Franklin Institute.* Vol. cxlv, No. 5, May, 1898. — *The Kansas University Quarterly.* Vol. vii, No. 2, April. — *Knowledge.* Vol. xxi, No. 151, May. — *Linnean Society of New South Wales.* Abstract of Proceedings, March 30, 1898. — *Medical and Surgical Reporter.* Vol. lxxviii, No. 3, April 16. — *Memorias y Revista de la Sociedad Cientifica.* "Antonio Alzate." Tome xi (1897–98), Nos. 1–4. Mexico, 1898. — *Michigan State Board of Agriculture.* Thirty-fifth Annual Report. Lansing, 1897. — *North American Journal of Diagnosis and Practice.* Vol. i, No. 4, April. St. Louis, Mo. — *The Open Court.* Vol. xii, No. 5, May. — *Proces-Verbaux des Séances de la Société Royale Malacologique.* Tome xxv (Ann. 1896). — *Publications of the Louisiana Historical Society.* Vol. ii, Pt. i, 1898 (1897). The Mounds of Louisiana, by Geo. E. Beyer. — *U. S. Geological Survey.* Eighteenth Annual Report, 1896–97. Vol. ii, Pt. v. Washington, 1897. — *The Zoölogist.* Fourth Series, Vol. ii, No. 16. London, April, 1898.

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DENTITION OF DEVONIAN PTYCTODONTIDÆ.

C. R. EASTMAN.

Three genera of Palæozoic Chimæroids, known only by remains of their dentition, constitute the, at present, imperfectly definable family *Ptyctodontidæ*. These are *Ptyctodus*, *Rhynchodus*, and *Palæomylus*, distributed throughout the middle and upper Devonian of Northern Europe and North America. The "jaws," or dental plates as they are more properly called, are rarely well preserved, and invariably occur in the detached condition. The solitary instance of four teeth associated in a group, as noted by Newberry in the type species of Rhynchodus, suggested the inference that in this genus, at least, the upper and lower dental plates were similar, each pair being directly united at the symphysis without the intervention of other teeth or plates. It has likewise been presumed that the dental plates of Ptyctodus were suturally united at the symphysis, but the conformation of this region and distinctions between upper and lower jaws, or even between rights and lefts in the case of detached tritors, have not yet been made out. Neither have dorsal fin-spines, such as occur in most other Chimæroids, been positively established as belonging to this family.

Recently a large amount of new material has come under the writer's observation which throws light on some of these points and prompts the present communication. The bulk of this material was obtained by the writer last summer from the State Quarry fish-bed, as it is called, discovered by Prof. Samuel Calvin in the Devonian of Johnson County, Iowa, and described by him in the seventh volume of the *Iowa Geological Survey Reports* and elsewhere ; for the second source of supply, the best thanks of the writer are due to Messrs. Edgar E. Teller and Charles E. Monroe, of Milwaukee, Wis., who very generously placed their private collections of fossil fishes at the disposal of the Museum of Comparative Zoology, and were influential in securing still further donations. Lastly, the inexhaustible stores of this same museum were drawn upon for a number of undescribed European fish remains, most of which belong to the famous Schultze Collection purchased in 1871. It will be convenient to group the notes which follow under their proper generic headings, beginning with the typical form Ptyctodus.

PTYCTODUS, Pander (1858).

(1) *P. obliquus.* — This, the type species, was illustrated by Pander [1] in two well-executed plates in 1858, as far as the fragmentary Russian material would then permit. Only two of the figured specimens show part of the symphysial region,[2] and these were not unnaturally supposed to indicate a distinct species from the remainder. This mistake, however, was rectified by A. S. Woodward in his *Catalogue of Fossil Fishes*, where a diagrammatic view of the symphysis in the left lower jaw of an imperfect specimen is given.[3] All of Pander's tritors are of the left lower jaw, excepting Figs. 1, 3, and 11, which belong to the right. The orientation of Fig. 6, however, is doubtful.

(2) *P. major.* — A dental plate considerably larger than any

[1] Pander, C. H. *Die Ctenodipterinen des devonischen Systems.* St. Petersburg, 1858.

[2] *Loc. cit.*, Pl. VIII, Figs. 10, 12.

[3] Woodward, A. S. *Catalogue of the Fossil Fishes of the British Museum*, vol. ii, Pt. ii, p. 38. 1891.

of the Russian forms described by Pander, but lacking the symphysis and having the tritoral area imperfect, was made by Rohon the type of a second European species, *P. major.*[1] Apparently the left lower jaw is portrayed in the illustrations, although as far as one may judge from Pl. I, Fig. 2, of Rohon's paper the direction of the tritoral punctæ is forward and outward instead of forward and inward. This character, however, as will presently be shown, is not an infallible clue to the orientation. The same author also mentions the occurrence of certain dorsal fin-spines having a tuberculated ornament, which he thinks may possibly have pertained to this genus.

(3) *P. molaris* (Figs. 28–30). — Yet another European species is that recently figured by the writer under the name of *P. molaris*,[2] from the Devonian of Prüm, in the Eifel District of Rhenish Prussia. The type specimen (Fig. 28) is a very perfect dental plate contained in the Schultze Collection, now the property of the Museum of Comparative Zoology. It represents the left lower jaw and is 6 cm. in length, but at least 1 cm. has been broken away from the posterior end. Its maximum thickness, which occurs just below and behind the tritor, is 1.2 cm. The tritoral punctæ are directed forward and outward, as in *P. major.* The forward portion of the tritoral area has been injured by abrasion, and so, too, has the cutting edge, which extended from the anterior end of the tritor as far as the symphysial beak, a distance of rather less than 2 cm. The tritor itself in this specimen is 2.4 cm. long, and its maximum width .7 cm. The outer face of the jaw is comparatively straight, the inner slightly bowed inward posteriorly. Fine concentric markings having a more or less longitudinal direction, such as occur in all well-preserved Ptyctodus jaws, can with difficulty be made out on both faces, owing to an adventitious glaze which covers the fossil.

This specimen has the anterior portion exceptionally well preserved. The front margin is slightly rounded, extends upward to form a strong prehensile beak, and also projects

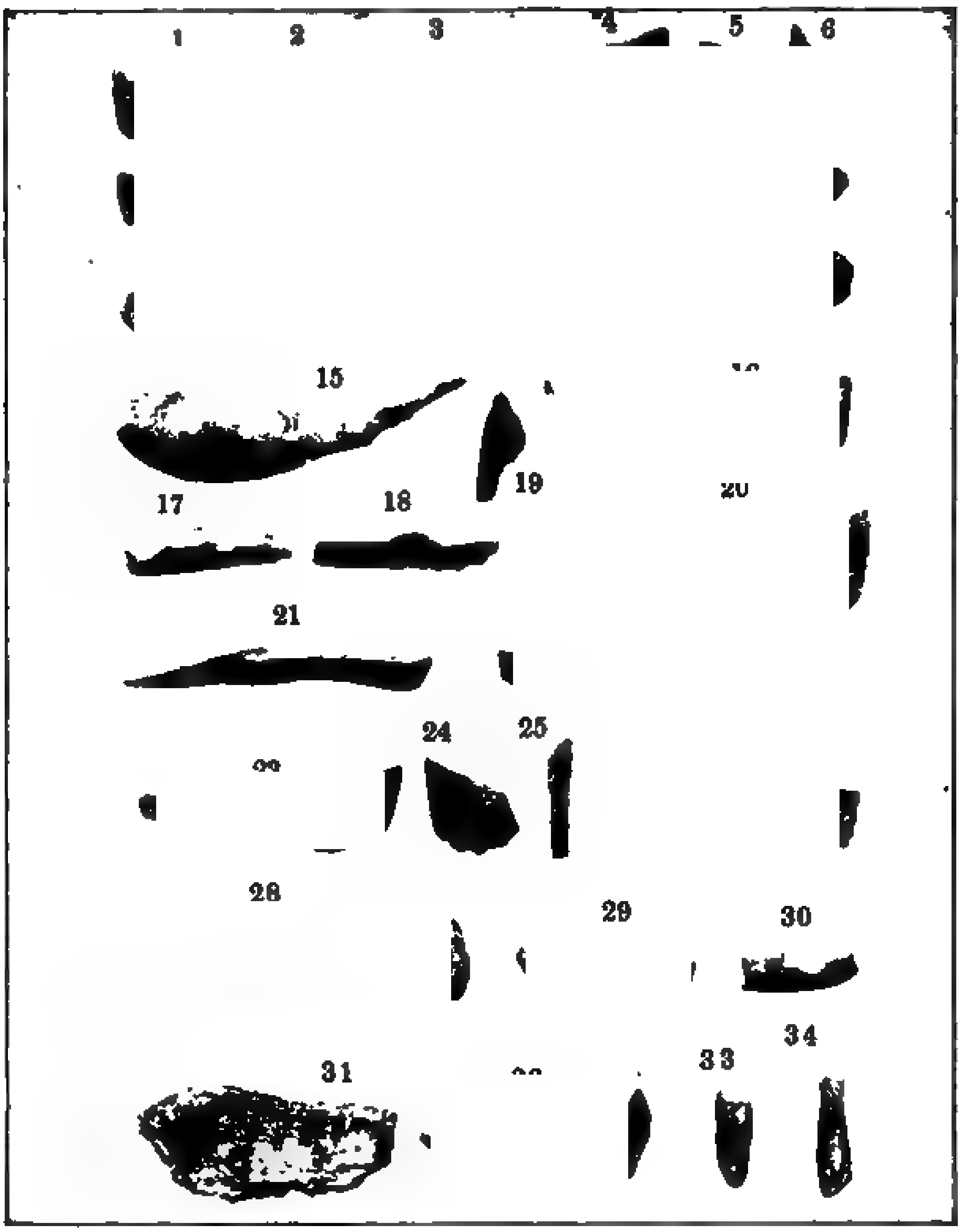
[1] Rohon, J. V. Beitrag zur Kenntnis der Gattung Ptyctodus, *Verhandl. mineral. Gesellsch. St. Petersburg* [2], vol. xxxiii (1895), pp. 1–16.

[2] *Ann. Rep. Iowa Geological Survey*, vol. vii (1897), p. 115, Fig. 10 *B.*

downward below the general level of the base, so as to provide a solid basis of attachment with its counterpart on the right side of the jaw. Distinct traces of this symphysial attachment are seen on the inner face in the form of a beveled band 4 mm. wide, running parallel with the front margin (see Fig. 28). There is no thickening on the inner face of the jaw at the symphysis, and in consequence the two upper dental plates must have been in close proximity to each other throughout the anterior portion of their length, in order to have permitted the beaks of the lower jaw to bite outside of them, which we know from other species must have happened. Although an excavated area appears on the outer face of the specimen behind the beak and below the cutting edge, yet this is plainly not due to wear, the boundaries being too sharply demarcated for that, and is therefore to be regarded as the natural configuration of this region in the present species. Other species, however, so far as known, have the outer face perfectly smooth, all traces of wear against the upper dental plate being confined to the inner side of the cutting edge. No upper jaws referable to this or any other European species have yet been encountered, but detached tritors are not uncommon.

(4) *P. calceolus* (Figs. 1–17). — This well-known species, the only one yet described from this country, is tolerably abundant in the Hamilton Limestone of the Upper Mississippi Valley and Manitoba; but prior to the discovery of the State Quarry fauna, near North Liberty, Iowa, was never met with except in a fragmentary condition. The reason for this is because the tissue surrounding and in advance of the tritors is vascular and soft; besides this the dental plates are considerably attenuated between the tritor and symphysial beak, and hence are extremely liable to be broken here through destructive agencies. Detached symphyses occur in the State Quarry bed, to be sure, but are vastly outnumbered by separate and, for the most part, abraded tritors. Out of more than 5000 specimens of Ptyctodus collected at this locality only about 50 showed the symphysial region, and of these but four belonged to the upper jaw. Approximately perfect dental plates are therefore of the utmost rarity.

The largest complete dental plate belonging to this species that the writer has seen is that shown in Fig. 15; it is about



FIGS. 1-17. — *Ptyctodus calceolus*, N. and W. Figs. 18-27. — *P. compressus*, sp. nov. Figs. 28-30. — *P. molaris*, Eastman. Figs. 31-34. — *P. panderi*, sp. nov. × ½.

7 cm. in length and 1.5 cm. in maximum width. The tritoral area measures 3 × .8 cm., and the anterior cutting edge is about two-thirds as long as the tritor. The specimen shown in Fig. 16 is 5.5 cm. long; that figured in the preliminary

paper on the State Quarry fauna already referred to[1] represents an average-sized individual 4.5 cm. in length. Upper dental plates (Figs. 12, 13), as far as their characters can be made out from the meager material at hand, do not differ materially from those described below as *P. ferox*, excepting, of course, that they are smaller, and are conformable to the lower jaw in curvature. The following remarks are, therefore, to be understood as applying exclusively to the lower dental plates.

Viewed from above, the curvature of the lower dental plates is seen to be more or less sigmoidal, the median line being in the left ramus ʃ-shaped, and in the right ʅ-shaped. The outer face is usually straighter and more nearly vertical than the inner. Very frequently the bony tissue enclosing the tritor is thickened so as to form a slight convexity on the inner posterior face, and its outline sweeps around posteriorly as an independent curve beyond the median line of the tritor, until it finally becomes merged with the less-rounded outer face of the jaw. The intersection of these curved outlines forms superiorly a peaked ridge just behind the tritoral area (Figs. 3, 16, 17) ; and it is to be noted that this ridge always lies externally to the median line of the tritor, or, to express it differently, the tritoral area tapers posteriorly toward the inside wall of the jaw, and is nearer to that side than the outer.

The tritoral area occupies nearly the full width of the upper surface of the jaw and partakes of the same curvature. Starting from behind, it curves first inwardly for about one-half its length, and then reverses this direction so that the anterior extremity tapers outward, and as the more arcuate boundary obviously lies on the inner face of the jaw, we are furnished with a convenient clue to the orientation in the case of detached tritors. In general, the parallel laminæ, or rows of punctate which indicate them superficially, are directed forward and inward, but exceptions to this rule are not uncommon, owing to irregularities in the arrangement of the medullary canals and inequal wearing away of the triturating surface. The latter cause is a powerful determinant in affecting the superior aspect of the tritors.

[1] *Ann. Rep. Iowa Geological Survey*, vol. vii (1897), p. 115, Fig. 10 *A*.

Just in front of the tritors the jaw is constricted, the inner face bending in close to the outer, which remains nearly straight, or may even curve slightly outward. Young forms have the constriction less marked than adults, since it becomes still further narrowed through wear. As already remarked, the outer face, which continues nearly vertical and smooth in advance of the tritors and terminates superiorly in a knife-edge, clearly never came in contact with the opposing upper dentition, since all evidences of wear are confined to the inner face. Young forms have a relatively shorter cutting edge than full-grown individuals, indicating that the symphysis became pushed further forward with age. The cutting edge slopes rapidly upward in front and terminates in a sharp prehensile beak. Below, at the symphysis, there is a projection similar to that noticed in *P. molaris*, for the purpose of strengthening the symphysial attachment ; and the front margin joining these two projections is straight, or very nearly so, instead of convex as in the European species. The inner face of the symphysis is thickened and rounded in order to separate the rami sufficiently to close outside the upper dental plates. Two vertical lines sometimes appear near the front margin in well-preserved specimens, and include between them a wedge-shaped area having apparently a denser structure than the surrounding tissue. No beveling has yet been observed on any of the specimens to indicate a sutural union at the symphysis. Either such traces have been effaced by accident, or the dental plates were simply apposed and held in place by ligaments. Illustrations of the symphysial region in different specimens are given in the accompanying figures.

(5) *P. compressus*, sp. nov. (Figs. 18–27). — Besides *P. calceolus*, two new species occur, although in lesser profusion, in the State Quarry bed, and one of them is found also in the Hamilton Limestone of Milwaukee. These new forms, which we will call *P. compressus* and *P. ferox*, are interesting on account of being transitional to the genera Rhynchodus and Palæomylus, respectively. The tritors in *P. compressus* are relatively narrower and longer than in *P. calceolus*, and between them and the symphysis a long, sharp, cutting edge is formed

by the lateral wall of the jaw. In all other species the knife-edge is shorter than the tritoral area, but in the present form the cutting edge is never shorter, and may be as much as one-fourth longer than the tritors. In the lower jaw it is the outside and in the upper the inside wall which is thus sharpened into a razor edge. As a whole, the jaws are straighter than in *P. calceolus*, and the symphysial region differently formed, as is apparent from the figures given herewith, the originals of which are preserved in the Museum of Comparative Zoology, and were all collected by the writer near North Liberty, Iowa.

Fig. 35. — *Ptyctodus ferox*, sp. nov. Left upper dental plate. × ½.

(6) *P. ferox*, sp. nov. (Figs. 35–40). — Much larger, heavier, and rarer than any of the foregoing is the species which we will call by this name. Less than a dozen examples have been obtained, all told, from the two localities where they occur, namely, the State Quarry fish-bed and the Hydraulic Cement quarries of Milwaukee, Wis. Those from the latter horizon are exceptionally well preserved, and were obtained by Messrs. Teller and Monroe. One of the four upper dental plates in Mr. Teller's collection (shown in Fig. 35) was very kindly presented by him to the Museum of Comparative Zoology, and is taken as the type of this species. Two other specimens in Mr. Teller's collection exceed this in size, one of them, measuring 11.5 cm. in a straight line, joining the extremities on a level with the triturating surface. The total length is estimated to have been about 14 cm.

This species illustrates the differences between upper and lower dental plates most admirably, and is, in fact, the first in

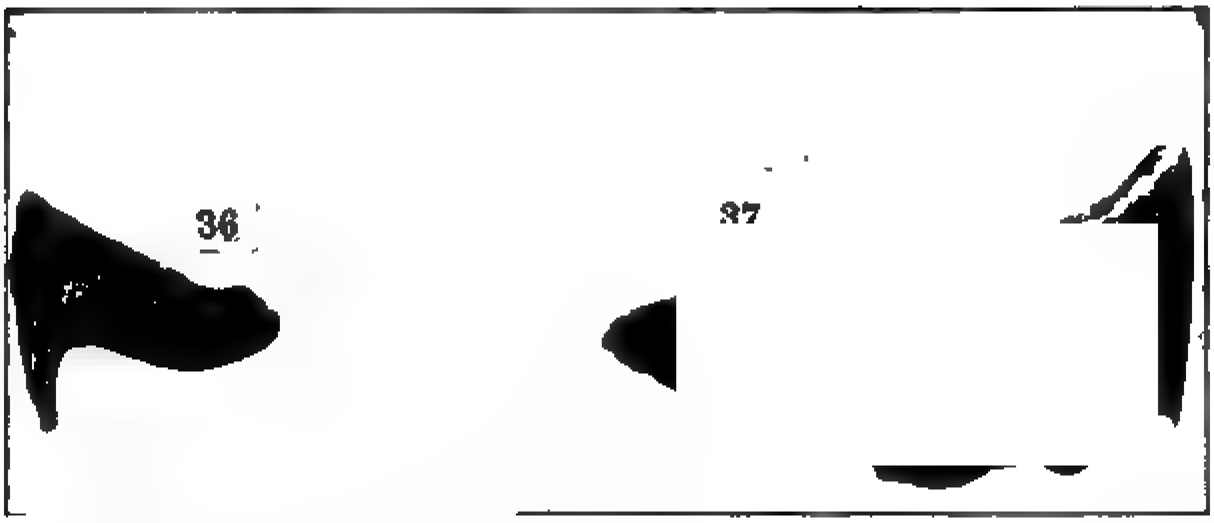
which these distinctions have been made out. The tritoral area of the upper jaw terminates anteriorly in a slight prominence or tubercle, situated somewhat nearer the outside than the inside face, and from this point onward as far as the crest of the symphysis a decided beveling is seen along the outer face (Fig. 35) where the beak of the lower jaw played against it. With increasing wear the beveling becomes converted into an excavation, the appearances suggesting that the jaws were movable, not only in a vertical, but also to some extent in an antero-posterior, direction.

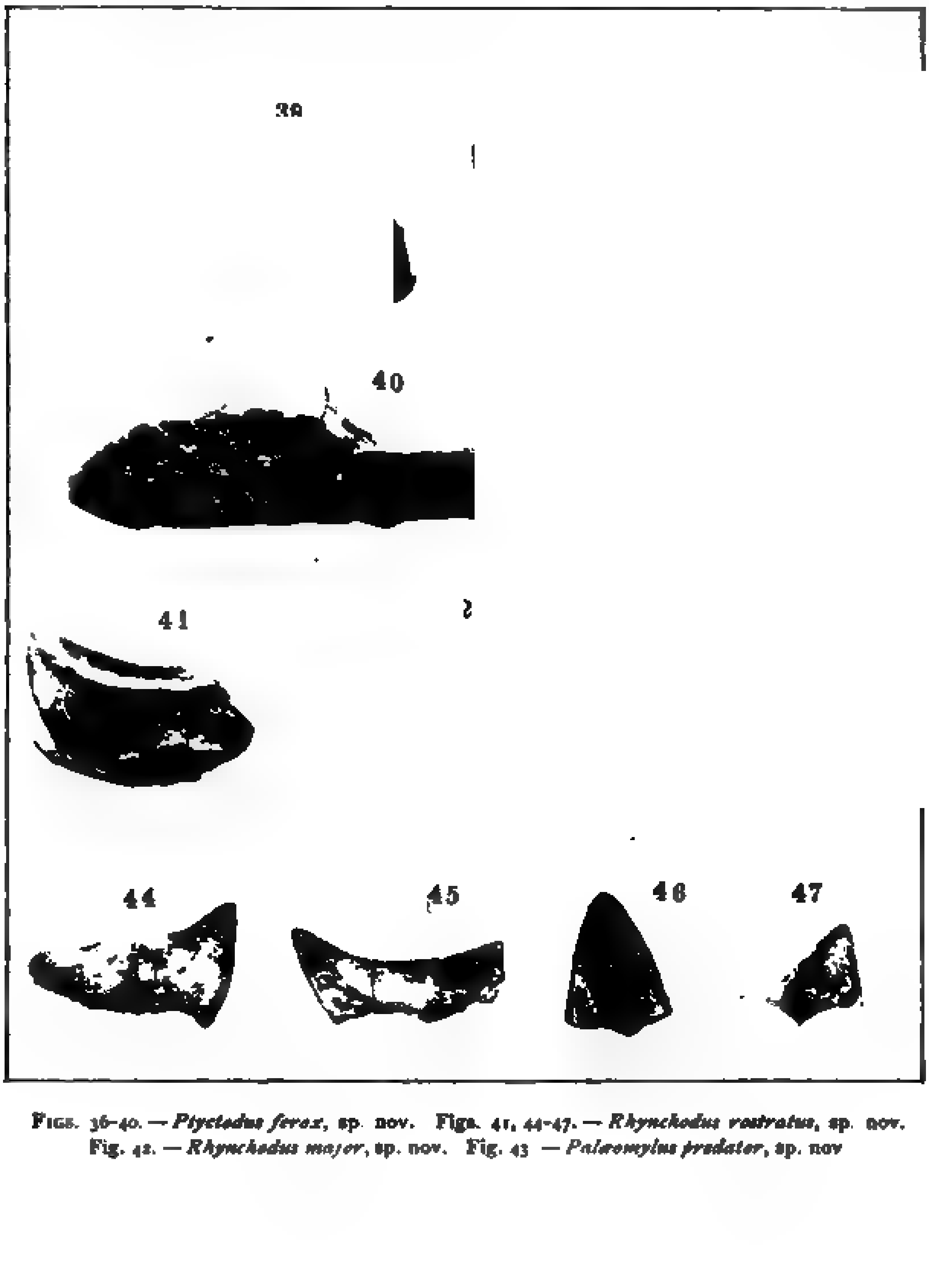
Anteriorly, the upper dental plates project forward and upward in a gently curved line, obviously for the purpose of strengthening the symphysial attachment, and they are also bent inwardly toward the front. As the inner face is but slightly thickened at the symphysis, the upper dental plates must have been more closely approximated anteriorly than the lower, thus permitting the prehensile beaks of the latter to pass by them on the outside, and allowing the cutting edge to close like the blade of a pair of shears. It is also plain that the rami of both jaws must have met at a rather acute angle anteriorly, forming a narrow V. The upper dental plates have a slight sigmoidal curvature, the posterior end flaring out and the symphysial portion being inflected inward.

The lower dental plate in this species is remarkable chiefly for its great height along the anterior margin, general straightness in an antero-posterior direction, and powerful prehensile beak. Superficially, it is marked by fine concentric striæ similar to those in Palæomylus, directed more or less parallel to the triturating surface and running at right angles to the second set commonly found in species of Ptyctodus. Four examples of the lower dental plate have come under the writer's observation, one of which is unusually heavy and corresponds in size to the largest of the upper dental plates. A medium and a small-sized individual are shown in Figs. 36, 37, and 39, the last two presenting the inner and outer aspects, respectively, of the same specimen. The original of Fig. 36 was found by Mr. C. E. Monroe near Milwaukee, and is preserved in his private collection. It represents a comparatively young indi-

vidual, being much smaller, thinner, and less worn on the triturating surface than Mr. Teller's specimens. Very remarkable indeed is the spiniform projection at the symphysis, which depends for such a distance inferiorly that the front margin actually exceeds the triturating surface in length. To give precise data, the total length in an antero-posterior direction is 3.4 cm.; length of triturating surface, 2.6 cm. (tritor, 1.5, cutting edge, 1.1); of anterior margin, 2.9; maximum thickness (width), 0.3 cm. Viewed from above, the curvature is seen to be only slightly sigmoidal and there is scarcely any thickening on the inner face at the symphysis. The tritoral punctæ are transversely directed, and the longitudinal ridge just back of the tritor nearly coincides with the median line. As is invariably the rule, beveling due to wear is confined to the inner face of the cutting edge.

The original of Figs. 37 and 39 belongs to Mr. Teller. Its outer wall is nearly straight for the greater portion of its length, but curves gently outward in advance of the tritoral area. This outward curvature is more strongly marked in another of Mr. Teller's specimens, recalling that shown in Fig. 3. Below the cutting edge, in about the center of the bony substance forming the outer wall of the jaw, is to be seen a circular pit or indentation 0.5 cm. in diameter and 0.2 cm. deep (see Fig. 39); and as a similar depression occurs in the same region of another specimen, the outlines being quite regular in both, it appears to have been a natural cavity. All of the lower dental plates have an uneven grinding surface, the principal slope being downward and outward. Other species have the slope usually downward and inward. The tritoral punctæ are nearly transverse in their direction, with a tendency toward forward and inward posteriorly. This is contrary to the conditions in the upper dental plates, which have the punctæ directed forward and outward. The original of Fig. 37 shows two vertical lines on the inner face of the symphysis which bound an area of apparently denser structure than the surrounding tissue and has a separate system of vascular canals. The thickening at this region has been reduced through abrasion, but it is seen from another specimen that a vertical triangular depression





FIGS. 36–40. — *Ptyctodus ferox*, sp. nov. Figs. 41, 44–47. — *Rhynchodus rostratus*, sp. nov. Fig. 42. — *Rhynchodus major*, sp. nov. Fig. 43 — *Palæomylus predator*, sp. nov

extended along the front margin on the inner side, very similar to that shown in the figures of Rhynchodus given herewith (Figs. 45, 46). Evidently, it lodged cartilage or ligaments for holding the plates firmly together at the symphysis.

From the foregoing account it will be seen that the general aspect of this species is suggestive of Palæomylus, which differs from Ptyctodus in having a much heavier and wider symphysial area, and is without definite tritors. That it forms a connecting link between these two genera we cannot doubt for a moment.

(7) *P. panderi*, sp. nov. (Figs. 31–34).—The type of this species, shown in Fig. 32, is contained in the Schultze Collection of the Museum of Comparative Zoology, along with about fifteen less perfect dental plates, tritors, or detached symphyses. According to a MS. label in German script, these specimens were obtained through a collector named Kröffges in 1859, and came from the Devonian of Berndorf and Gerolstein in the Eifel District. Evidently their description was at one time intended (perhaps by Hermann von Meyer, who had access to part of this collection), for they are marked with the MS. name of "*Ptyctodus panderi*, n. sp." This name may very appropriately be retained and validity given to it by the following brief diagnosis.

P. panderi, a species accompanying *P. molaris* in the Eifel Devonian, and related to it in the same way that *P. compressus* is to *P. calceolus*. Lower dental plates attaining a length of 6 cm., but commonly not more than 4 cm., and in height about 1.5 cm., with only a very slight sigmoidal curvature in an antero-posterior direction, and strongly compressed laterally. Outer face forms superiorly a sharp, nearly straight knife-edge extending from the tritoral area to the anterior beak, a distance of about equal length with the tritors. The cutting edge rises very slightly and suddenly to form the anterior projection, below which the anterior margin is moderately convex. With scarcely any thickening on inner face at the symphysis, and inferior projection at this region not observed (perhaps wanting ?). Upper dental plates likewise thin and nearly rectilinear. This species forms with *P. compressus*, from which it differs

principally in the configuration of the symphysial area, a transitional stage between *Ptyctodus* and the next following genus.

RHYNCHODUS, Newberry (1873).

(1) *R. secans.* — This species, which is the type of the genus, is not uncommon in the Corniferous Limestone of Ohio, and is interesting for having furnished a group of four teeth preserved in natural association. There is but little difference in the form of upper and lower dental plates, and both terminate anteriorly in prominent beaks. It is probable that the latter character is not merely specific but generic, as *R. excavatus* also has sharp beak-like projections in both jaws. An indentation occurs just back of the beak in the upper jaw where the terminal point of the lower came in contact with it, thus proving that the upper jaw protruded forward in advance of the lower, as in Ptyctodus. The lower dental plate is deeper than the upper, which was limited vertically by the cranial wall, and its triturating surface is frequently more uneven. Its inner face is beveled away through contact with the upper jaw, the two working together like blades of shears.

A knowledge of this latter character compels us to dissent from Newberry's determination of one of his figures[1] as a "left maxillary tooth" in spite of its having a nearly straight cutting edge. Owing to the fact that it is beveled on the inner face and is not cut away behind the anterior beak we prefer to regard it as the right lower dental plate.

(2) *R. occidentalis.* — This species has never been figured, and the writer has been unable to obtain examples of it. Newberry's original description is as follows[2]: "Teeth of small size, much compressed. Anterior margin slightly curved, but nearly vertical. Superior margin gently arched downward from the prominent anterior point, forming a much-compressed triturating surface or edge. Posterior portion of upper margin acute-edged. Exterior lateral surface striated obliquely backward.

[1] Newberry, J. S. *Rep. Geol. Surv. Ohio*, vol. i, Pt. ii (Paleontology), Pl. XXVIII, Fig. 1 (1873). Also figured in *Mon. U. S. Geol. Surv.*, vol. xvi (1889), same number of plate and figure.

[2] *Annals N. Y. Acad. Science*, vol. i (1878), p. 192.

Basal margin formed by the edges of external and internal laminæ, of which the edges are broken and irregular. From the Hamilton Limestone, Waverly, Iowa."

(3) *R. excavatus.* — Our knowledge of this species is confined to the single imperfect dental plate described by Newberry,[1] and recognized by him as belonging to the left ramus of the lower jaw. Perfectly preserved specimens are very rare, it would seem, as most of the material collected by Messrs. Teller, Monroe, and Slocum from the Cement quarries of Milwaukee are deficient to a greater or lesser extent.

As far as can be learned from the materials at hand, only the lower dental plates are excavated along the cutting edge in the manner described by Newberry, and the sinus varies somewhat in length among different individuals. The lower jaw is further characterized by having an inferior projection at the symphysis, as in Ptyctodus. It is greatly prolonged downward, being, in fact, spiniform, and recalling the conditions in *P. ferox;* in one of Mr. Monroe's specimens it occupies fully half of the front margin. Of what practical advantage such a contrivance could be it is difficult to perceive. Vermiculating furrows do not occur on the surface of well-preserved specimens, but may be sometimes brought out through corrosion or abrasion. The outer surface is normally smooth, or is marked only with very fine concentric striæ.

Lower dental plates have the cutting edge beveled off on the inner face only. Upper dental plates show distinct traces of wear on the outer face, which terminate abruptly, however, at a slight distance behind the anterior beak. This proves that the beaks in upper and lower jaws were not directly opposed to one another, but those of the upper protruded in front of the lower when the mouth was closed. We are led to infer from the conditions in *R. secans* that the beaks in both jaws were more or less similar, but as none of the upper beaks are completely preserved in the material at hand, this inference must remain for the present unconfirmed. The cutting edge

[1] *Rep. Geol. Surv. Wisconsin*, vol. ii (1877), p. 397. *Annals N.Y. Acad. Science*, vol. i (1878), p. 192. *Mon. U.S. Geol. Surv.*, vol. xvi (1889), p. 50, Pl. XXIX, Fig. 1.

of the upper dental plate is remarkably straight and sharp. None of the specimens appear to have exceeded 5 cm. in length.

(4) *R. rostratus*, sp. nov. (Figs. 41, 44–47). — The characters of this species, as determined from nearly a score of dental plates in the Schultze Collection in the Museum of Comparative Zoology, are as follows: Lower dental plates attaining a length of about 6 cm. and a height of about 2 cm.; perfectly straight, laterally compressed, smooth and glistening externally, or with only very fine concentric striæ. Superior margin semicircular or nearly so, being concave upward; front margin regularly convex and terminating above in a sharp projecting beak. Cutting edge occupying nearly the entire superior margin, very sharp, and beveled on the inner face through wear. Inner face slightly thickened at the symphysis, but never wider than 0.5 cm., otherwise plane like the outer. A peculiar lanceolate or tongue-shaped cavity, having the apex directed superiorly, occurs on the lower half of the symphysial area; its roughened surface suggests that it served for the reception of ligaments which held the two rami together at the symphysis. Upper dental plates unknown.

Two rather imperfect specimens in the Schultze Collection are interesting from having been figured by Hermann von Meyer,[1] under the mistaken impression that they were swimming appendages of his so-called "Physichthys Höninghausi." All the originals on which his descriptions were based are preserved in the Cambridge Museum, and obviously belong to the three genera, Macropetalichthys, Pterichthys, and Rhynchodus, as was first pointed out by A. S. Woodward[2] a few years ago.

This species is known at present only from the Eifel Devonian, the Cambridge specimens having been found at Pelm, Gerolstein, and Berndorf.

(5) *R. major*, sp. nov. (Fig. 42). — This form accompanies the preceding in the Eifel Devonian, the typical locality being Prüm. Complete dental plates have not been recovered as yet,

[1] Meyer, von, H. Physichthys Höninghausi, etc., *Palæontographica*, vol. iv (1856), Pl. XV, Figs. 9, 10.

[2] *Geol. Magazine*, [3] vol. vii (1890), p. 459.

but two large-sized fragments in the Schultze Collection furnish sufficient evidence of a distinct species. They indicate a jaw of about twice the size of *R. rostratus*, and are heavier in proportion. Concentric striæ are more prominent than in the last-named species, and one of the specimens shows minute folds crossing the striæ at right angles. These have the appearance of fine cracks on the gently rounded anterior margin where they have been somewhat corroded. The symphysis is constituted similarly to that of the preceding species. The eighteen or more examples of *R. rostratus* in the collection are too nearly of a size to be regarded as all young forms, of which *P. major* is the adult, and it would be strange indeed if full-grown individuals were outnumbered ten to one by more readily destructible immature examples. Close resemblances exist, however, between the anterior regions of *R. rostratus*, the present species, and *Palæomylus predator* (Fig. 43).

(*To be continued.*)

A LIST OF THE MAMMALS OF LABRADOR.

OUTRAM BANGS.

In the *Geological Survey of Canada*, Annual Report, New Series, vol. viii, 1895, pp. 313 L. to 321 L., Mr. A. P. Low gives a "List of Mammalia of the Labrador Peninsula, with brief notes on their distribution, etc." This list, appearing as it does in Mr. Low's valuable report upon Labrador, and being based very largely upon his personal observations in the field, is of great importance, and it is much to be regretted that so many of the names used are archaic — often misleading. The volume did not appear until the summer of 1897, although probably Mr. Low's list was written some time before that. The list, however, does not include several Labrador mammals, descriptions of which had appeared in print prior to 1895.

It is with such corrections and additions that I deal principally in the present paper, endeavoring to bring Mr. Low's list up to date. Much is still to be learned of the Labrador mammals, and the present list is doubtless incomplete. Only one of the species given by Mr. Low is dropped, — the musk ox, — Mr. Low himself saying that it is extremely doubtful if it ever occurred in Labrador. I follow Mr. Low in including several other species that occur in southwestern Labrador only, as the moose, the fisher, and the skunk. Doubtless there are many more of this category. No material is available from southern Labrador, and the mammals of that region are little known. It is more than probable that most of the usual forms of the upper Canadian and lower Hudsonian faunas occur there. At Lake Edward, Quebec, I took such species as *Microtus pennsylvanicus fontigenus*, *M. chrotorrhinus*, *Evotomys gapperi*, *Synaptomys fatuus*, *Peromyscus canadensis abietorum*, *Sorex hoyi*, *S. albibarbis*, and *Blarina brevicauda*. Without doubt the ranges of many if not all of these extend along the shore of the Gulf of St. Lawrence, and thus enter Labrador.

Two mammals are added by me as new forms — the Labrador black bear and the marten of North Labrador.

I am able to add but little to Mr. Low's account of most of the mammals, and have confined myself chiefly to recording the localities at which specimens have been taken, or the different species have been observed, quoting freely from Mr. Low.

Literature.

In addition to Mr. Low's list, the following are the more important references to Labrador mammalia that have lately appeared:

1867. A. S. Packard. List of the Vertebrates Observed at Okak, Labrador, by Rev. Samuel Weiz, with annotations by A. S. Packard, Jr., M.D. *Proc. Boston Soc. Nat. Hist.* pp. 264–277. March, 1867.

1883. W. A. Stearns. Notes on the Natural History of Labrador. *Proc. U. S. Nat. Mus.* Vol. vi, pp. 111–137. Aug. 1, 1883.

1889. C. Hart Merriam. A New Genus and Four New Species of Arvicolinæ. *North Am. Fauna.* No. 2, pp. 27–35. 1889. (Contains descriptions of *Phenacomys celatus*, *P. ungava*, and *P. latimanus*.)

1891. A. S. Packard. The Labrador Coast. N. D. C. Hodges, Pub., New York. (In both of Packard's and in Stearns's works lists of the Labrador mammalia are given. These lists are much alike, are very imperfect, and were evidently taken one from the other. They call for no special comment, except that the raccoon (*Procyon lotor*) is given from Square Island. This is probably an error, as the locality is far beyond the known northern limit of range of the raccoon.)

1894. F. W. True. Mictomys innuitus, New Genus and Species from Fort Chimo, Labrador. *Proc. U. S. Nat. Mus. Wash.* Vol. xvii, No. 999. Advance sheet. April 26, 1894.

1896. Sam'l N. Rhoads. The Polar Hares of Eastern North America, with Descriptions of New Forms. *Am. Nat.* pp. 251–256. March, 1896. (Containing description of *Lepus arcticus bangsii.*)

1896. Sam'l N. Rhoads. Synopsis of the Polar Hares of North America. *Proc. Acad. Nat. Sci.* pp. 351–376. Philadelphia, 1896. (With fuller accounts of the different forms, plates of skulls, etc.)

1896. O. Bangs. Preliminary Description of a New Vole from Labrador. *Am. Nat.* Vol. xxx, p. 1051. Dec. 5, 1896.

1897. Vernon Bailey. Revision of the American Voles of the Genus *Evotomys. Proc. Biol. Soc. Wash.* pp. 113–138. May 13, 1897. (Containing descriptions of *Evotomys ungava*, by Bailey, and *E. proteus*, by Bangs.)

1897. O. BANGS. On a Small Collection of Mammals from Hamilton Inlet, Labrador. *Proc. Biol. Soc. Wash.* pp. 235–240. Sept. 17, 1897.

1898. VERNON BAILEY. Preliminary Description of *Microtus pennsylvanicus labradorius*. *Proc. Biol. Soc. Wash.* Vol. xii, p. 88. April 30, 1898.

MATERIAL.

The first important collection of mammals from Labrador was the one made in 1882 by L. M. Turner, while stationed at Fort Chimo, Ungava. Several new forms have been described from this material, which is in the National Museum at Washington. Unfortunately, it is of rather poor quality; the small mammals are preserved in alcohol, and the larger ones are mostly flat skins, usually without skulls, and often very imperfect.[1]

In the summer of 1895 Mr. C. H. Goldthwaite made a collection of mammals for the Bangs collection at Rigoulette, on Hamilton Inlet, upon which I have already reported.

In the summer of 1897 Mr. J. D. Sornborger, while in northern Labrador, obtained a good many skulls of the larger mammals, principally by purchasing them from the Eskimo. These are also in the Bangs collection.

Besides these lots, about all the available material from Labrador consists of a few specimens in the collection of the Geological Survey of Canada, which Prof. John Macoun has kindly sent me for examination. Among them is one specimen of *Zapus insignis*, and one of *Peromyscus maniculatus*.

PHYSICAL GEOGRAPHY.

In view of Mr. Low's careful descriptions of every part of the Labrador Peninsula it is useless to say more than a word in a very general way about the features of the region. The country consists, roughly speaking, of three general kinds: the barrens, the semi-barrens, and the forest — mostly of spruce and fir. Descriptions of any particular region can be found in Mr. Low's report.

[1] Through the kindness of Mr. F. W. True and Mr. Gerrit S. Miller, Jr., I have had an opportunity of examining Turner's material.

The distribution of the different species is still very imperfectly known, but of course many species find their northern limit where the forest ends, while others are confined to the barrens and semi-barrens. There is quite a difference between the smaller mammals from the region about Hamilton Inlet and those from Fort Chimo, but just where the line is to be drawn that divides the two sets of forms I am at present unable to say. Many of the forms in these two regions appear, however, to be specifically distinct.

1. MONODON MONOCERAS Linn. Narwhal.
Monodon monoceras Linn. Ed. x, p. 75. 1758.

Common all along the Labrador coasts.

2. DELPHINAPTERUS LEUCAS (Pallas). White porpoise.
Delphinus leucas Pallas. "*It.* iii, p. 84, t. iv."

Common everywhere along the Labrador coasts.[1]

3. LEPUS AMERICANUS AMERICANUS Erxl. American varying hare.
Lepus americanus Erxl. *Syst. Anim.* p. 330. 1777.
Type Locality. South side of Hudson Strait.

Common throughout the wooded region and extending into the edge of the barrens. Goldthwaite took fourteen specimens at Hamilton Inlet.

4. LEPUS ARCTICUS BANGSII Rhoads. Newfoundland Arctic hare.
Lepus arcticus bangsii Rhoads. *Am. Nat.* p. 253. March, 1896.
Type Locality. Codroy, Newfoundland.

The dark-colored, more southern form of the Arctic hare is of general distribution in the barrens and semi-barrens of Labrador, occasionally reaching as far south as Hamilton Inlet. Turner took specimens at Fort Chimo and Solomon Island.

5. ERETHIZON DORSATUS (Linn). Canada porcupine.
Hystrix dorsata Linn. *Syst. Nat.* Ed. x, vol. i, p. 57. 1758.

[1] Several other cetaceans are given by Packard in his list of the mammals of the Labrador coast. Mr. Low does not include these, although he often quotes from Packard and from Stearns. I therefore follow Mr. Low in omitting them.

Common from the St. Lawrence north to the semi-barrens.

Turner took a specimen at Fort Chimo. This skin (no skull can be found) is in the National Museum, where I examined it. It is nearly uniform black, with but very few lighter rings on the long hairs and quills. The densely woolly hair is very long, entirely concealing the quills. The tail is short.

I feel sure this porcupine represents a good geographical race. Skulls of the porcupine from as far north as Nova Scotia begin to show differences from those of New Hampshire and Maine, and undoubtedly these characters will prove to be carried farther still in Labrador specimens.

6. ZAPUS HUDSONIUS HUDSONIUS (Zimmermann). Jumping mouse.

Dipus hudsonius Zimmermann. *Geog. Gesch.* Vol. ii, p. 358. 1780.

Apparently not common. Goldthwaite took three at Rigoulette, Hamilton Inlet, all in the spruce woods.

7. ZAPUS INSIGNIS Miller. Woodland jumping mouse.

Zapus insignis Miller. *Am. Nat.* Vol. xxv, p. 742. 1891.

Low took one specimen at Hamilton River. This is mounted and in the Geological Survey of Canada collection. I have examined it and do not feel at all sure that more specimens would not show the Labrador form to be a good sub-species.

8. FIBER ZIBETHICUS ZIBETHICUS (Linn). Muskrat.

Castor zibethicus Linn. *Syst. Nat.* Ed. xii, vol. i, p. 79. 1766.

Low says of the muskrat that it is common in the southern wooded region, but rare along the Upper Hamilton River.

Goldthwaite took one at Rigoulette. Turner took it at Fort Chimo.

9. DICROSTONYX HUDSONIUS (Pallas). Hudson Bay lemming.

Mus hudsonius Pallas. Glir. p. 203. 1778.

Found throughout the barrens and on the treeless hills, south, at least, to Hamilton Inlet.

Low took it at Lake Michikamaw. Goldthwaite trapped four at Rigoulette. I have also examined a mounted specimen from Port Burwell, collected in 1884 by Dr. Bell, in the Geological Survey of Canada collection.

10. SYNAPTOMYS (MICTOMYS) INNUITUS (True). True's lemming.

Mictomys innuitus True. *Proc. Nat. Mus.* Vol. xvii, No. 999. Advance sheet. April 26, 1894.

Type Locality. Fort Chimo, Labrador.

Known at present only by the type and one specimen, not typical, taken at Rigoulette by Goldthwaite.

11. MICROTUS ENIXUS Bangs. Larger Labrador vole.

Microtus enixus Bangs. *Am. Nat.* Vol. xxx, p. 105. 1896.

Type Locality. Rigoulette, Hamilton Inlet, Labrador.

Probably common throughout all the wooded regions, its range extending north to the semi-barrens and meeting that of the next form — *M. pennsylvanicus labradorius.*

Goldthwaite took a large series at the type locality. I have examined three specimens in the collection of the Geological Survey of Canada, from "50 miles north of Fort George." Turner took quite a number at Fort Chimo.

12. MICROTUS PENNSYLVANICUS LABRADORIUS Bailey. Small Labrador vole.

Microtus pennsylvanicus labradorius Bailey. *Proc. Biol. Soc. Wash.* p. 88. April 30, 1898.

Type Locality. Fort Chimo, Ungava, Labrador.

This little vole probably occurs only in the barrens and semi-barrens. It can be told from *M. enixus* by its smaller size, shorter, more hairy tail, by its smaller, flatter skull, with shorter rostrum and nasals, and smaller, shorter incisive foramina, differently shaped zygoma, and larger auditory bullæ. There are probably color differences also, but I have seen alcoholic specimens only. Turner took many specimens at Fort Chimo.

13. EVOTOMYS UNGAVA Bailey. Ungava red-backed mouse.

Evotomys ungava Bailey. *Proc. Biol. Soc. Wash.* p. 130. 1897.

Type Locality. Fort Chimo, Labrador.

Probably restricted to the barrens and semi-barrens. Turner reported the species to be abundant at Fort Chimo, but apparently did not send many specimens to Washington.

The differences between this and the next species appear to be as great as between any two members of the genus *Evotomys.*

14. Evotomys proteus Bangs. Hamilton Inlet red-backed mouse.

Evotomys proteus Bangs. *Proc. Biol. Soc. Wash.* p. 137. 1897.

Type Locality. Rigoulette, Hamilton Inlet, Labrador.

Very abundant at Hamilton Inlet, and probably throughout the wooded regions. Goldthwaite took a large series at Rigoulette.

15. Phenacomys latimanus Merriam. Small yellow-faced phenacomys.

Phenacomys latimanus Merriam. *North Am. Fauna.* No. 2, p. 34. 1889.

Type Locality. Fort Chimo, Ungava, Labrador.

Probably of general distribution in the drier semi-barrens. Known from Labrador only by the specimens sent to Washington by Turner.

16. Phenacomys ungava Merriam. Large yellow-faced Phenacomys.

Phenacomys ungava Merriam. *North Am. Fauna.* No. 2, p. 30. 1889. (Fort Chimo, Lab.)

Phenacomys celatus Merriam. *North Am. Fauna.* No. 2, p. 33. 1889. (Godbout, Quebec.)

Type Locality. Fort Chimo, Ungava, Labrador.

Taken at Fort Chimo by Turner, at Rigoulette by Goldthwaite, and at Groswater Bay (= Hamilton Inlet) by Dr. Coues (2 skulls).

Goldthwaite's series from Rigoulette, sixteen in number, were all caught in one place in the spruce woods. The adults are much larger than the type of the species from Fort Chimo, and may represent a larger, more southern, sub-species.

17. PEROMYSCUS MANICULATUS (Wagner). Labrador deer mouse.

Hesperomys maniculatus Wagner. *Weigmann's Archiv.* Vol. xi, 1845.

Type Locality. "The Moravian settlements in Labrador."

Unfortunately, this mouse is at present little known; neither Turner nor Goldthwaite took specimens. Low reports it as being common at Northwest River, Hudson's Bay Port. I have seen and examined but one example — a fine adult female from Great Whale River, in the collection of the Geological Survey of Canada. This specimen I have compared with the type of *Peromyscus texensis arcticus* Mearns, and the two appear to be identical.

The Great Whale River specimen of *P. maniculatus* (measured by me from a well-made skin) has the following dimensions: total length, 166; tail vertebræ, 74; pencil, 5; hind foot, 19.5. The type of *P. texensis arcticus* (measured by me from well-made skin): total length, 168; tail vertebræ, 73; pencil, 5; hind foot, 20. In color they agree exactly. The skull of the Great Whale River specimen is peculiar. It is very large, with an extremely broad, flat brain case and heavy rostrum. The molar teeth are also large. The skull of the type of *P. texensis arcticus* is in the skin, and at present I am unable to examine it. The shorter tail and different skull of *P. maniculatus* distinguish it from any of the members of the *canadensis* group.

For the present, until more material from Labrador is available, the question of the relationship of *P. texensis arcticus* and *P. maniculatus* cannot be settled, though it is probable that they are the same. One point is perfectly clear — that *P. maniculatus* is a splendid, distinct species.

18. CASTOR CANADENSIS Kuhl. Canadian beaver.

Castor canadensis Kuhl. *Beiträge zur Zoologie.* p. 64. 1820.

Low says the beaver is common in the wooded regions, and extends into the semi-barrens where food is found. I have seen no Labrador specimens.

19. ARCTOMYS MONAX MELANOPUS (Kuhl). Hudsonian woodchuck.

Arctomys melanopus Kuhl. *Beiträge.* p. 64. 1820.

Common in the country between Lake St. John and the East Main River, Low. I have seen no Labrador specimens; without doubt the form found there is *melanopus*.

20. SCIURUS HUDSONICUS HUDSONICUS Erxl. Northern pine squirrel; red squirrel.

Sciurus vulgaris ε. hudsonicus Erxl. *Mammalia*. p. 416. 1777.

Type Locality. Hudson Strait.

Common in the wooded regions and extending into the semi-barrens. Goldthwaite took specimens at Rigoulette. Turner took specimens at Fort Chimo and at Forks, Northwest River.

21. SCIUROPTERUS SABRINUS (Shaw). Severn River flying squirrel.

Sciurus sabrinus Shaw. *Gen. Zoöl.* Vol. i, p. 15 F. 1801.

Common in the valley of the Lower Hamilton River and about the head of Hamilton Inlet, Low. I have not seen any specimens from Labrador. Turner sent one to Washington; although catalogued, it cannot now be found.

22. SOREX PERSONATUS I. Geoff. St. Hilaire. Common shrew.

Sorex personatus I. Geoff. St. Hilaire. *Mém. Mus. d'Hist. Nat. Paris*. Vol. xv, p. 122. 1827.

Taken at Sandwich Bay by Low, at Rigoulette by Goldthwaite, and at Fort Chimo by Turner.

23. CONDYLURA CRISTATA (Linn). Star-nosed mole.

SOREX CRISTATUS Linn. *Syst. Nat.* Ed. x, vol. i, p. 53. 1758.

Goldthwaite saw and fully identified a star-nosed mole that the dogs had caught at Rigoulette. As he assures me there is not the slightest chance of a mistake in his identification, the species must be included.

24. MYOTIS LUCIFUGUS (Le Conte). Little brown bat.

Vespertilio lucifugus Le Conte. *Mc. Murtries Cuvier.* Appendix, p. 431. 1831.

Low supposed the bats seen by him on Hamilton River and at Lake Mistassini to belong to this species. I took this bat

at Lake Edward, Quebec, and Miller (*North Am. Fauna*, No. 13, p. 63) records it from Godbout and Ottawa, Quebec, and from James Bay, Ontario. It is also found in Newfoundland.

25. Myotis subulatus (Say). Say's bat.

Vespertilio subulatus Say. *Long's Exped. to Rocky Mts.* Vol. ii, p. 65, footnote. 1823.

Reported by Stearns from Natashquan. Miller (*North Am. Fauna*, No. 13, p. 76) records specimens from Mt. Forest and North Bay, Ontario, and Godbout and Ottawa, Quebec.

26. Alce americanus Jardine. Moose.

Alces americanus Jardine. *Nat. Library.* Vol. iii, p. 125. 1835.

Low is in doubt whether or not the moose enters the southwestern limits of Labrador. It is occasionally killed in the region about Lake Edward, Quebec.

27. Rangifer caribou (Gml.). Woodland caribou.

Cervus tarandus γ. *caribou* Gmelin. *Syst. Nat.* Vol. i, p. 177. 1789.

Reported by Low to now be very rare, — almost exterminated, — though formerly abundant throughout the wooded regions. Low also says that the destruction of the woodland caribou has resulted in the dying off, from actual starvation, of a large proportion of the interior Indians, which, in its turn, has caused a great increase in the numbers of the fur-bearing animals.

28. Rangifer arcticus (Richardson). Barren ground caribou.

Cervus tarandus var. a. *arctica* Richardson. *F. B. A.* Vol. i, p. 241. 1829.

According to Low, the barren ground caribou still ranges in immense herds over the barrens and semi-barrens, south to the Mealy Mountains, between Hamilton Inlet and Sandwich Bay.

29. Rosmarus rosmarus (Linn). Atlantic walrus.

Trichechus rosmarus Linn. *Syst. Nat.* Ed. xii, vol. i, p. 49. 1766.

Now restricted to northern Labrador, reaching south only to about Nachvak. Formerly abundant along the whole Labrador coast. A fine pair, ♂ and ♀, skulls in Bangs's collection, obtained by Sornborger from the Eskimo at Okak.

30. PHOCA VITULINA Linn. Harbor seal.

Phoca vitulina Linn. *Syst. Nat.* Vol. i, p. 38. 1758.

Common along the whole coast and in the lower parts of the rivers. It is also, according to Low, found in many of the fresh-water lakes of the interior, and the Indians assert that these fresh-water seals never leave the lakes. This should be carefully looked into, and it is to be hoped that collectors in Labrador may be able to take some of these fresh-water seals.

One skull in Bangs's collection from Okak, obtained by Sornborger from the Eskimo.

31. PHOCA (PUSA) HISPIDA Schreber. Ringed seal.

Phoca hispida Schreber. *Säugt.* Vol. iii, p. 312, Pl. LXXXVI. 1775. (*Vide* Thomas. *Zoölogist*, p. 102. 1898.)

Common along the entire Labrador coast.

32. PHOCA (PAGOPHILUS) GRŒNLANDICA Fabricius. Harp seal.

Phoca grœnlandica Fabricius. *Müller's Zool. Dan. Prod.* Vol. viii. 1776.

Common along the whole Labrador coast.

33. ERIGNATHUS BARBATUS (Fabricius). Bearded seal.

Phoca barbata Fabricius. *Müller's Zool. Dan. Prod.* Vol. viii. 1776.

Low reports this seal to be rare in the St. Lawrence and in southern Labrador, but more common northward — in Hudson Strait, Hudson Bay, and James Bay.

34. HALICHŒRUS GRYPUS (Fabricius). Gray seal.

Phoca grypus Fabricius. *Skriv. af. Naturh.-Selsk.* Vol. i, ii, p. 167, Pl. XIII, Fig. 4. 1791.

Rare along the Labrador coast.

35. CYSTOPHORA CRISTATA (Erxleben). Hooded seal.

Phoca cristata Erxleben. *Syst. Reg. Anim.* p. 590. 1777.

Not common along the Labrador coast.

36. THALARCTOS MARITIMUS (Linn). Polar bear; ice bear.

Ursus maritimus Linn. *Syst. Nat.* Ed. xii, vol. i, p. 70. 1766.

Low says the polar bear ranges south along the Atlantic coast of Labrador occasionally as far as the Strait of Belle Isle, and in Hudson Bay to Charleton Island. The species seldom goes far inland, except to produce its young. Sornborger told me that the polar bear is very common and resident in northern Labrador.

Four skulls in Bangs's collection, all obtained by Sornborger of the Eskimo at Hebron and Okak.

37. URSUS RICHARDSONII Mayne Reid. Barren ground bear.

Ursus richardsonii Mayne Reid. *Bruin: The Great Bear Hunt.* London, 1860. American Ed., pp. 260, 261. 1864.

Although no specimens have ever found their way into collections, there is no longer any doubt that a huge bear is found in the barrens of Labrador. Low says that the Mascaupee Indians have many tales of its size and ferocity. I can see no reasonable doubt that this bear is true *U. richardsonii*.

38. URSUS (EUARCTOS) AMERICANUS SORNBORGERI sub. sp. nov. Labrador black bear.

Type. From Okak, Labrador. Skull No. 7411, young adult (probably ♀), collection of E. A. and O. Bangs, obtained in the summer of 1897 by J. D. Sornborger from the Eskimo.

Subspecific Characters. The skull differs from that of true *U. americanus* from Maine, Nova Scotia, etc., in being smaller; very much shorter and broader; brain case short and broad; zygoma widely spread; frontal region low, broad, and flat, with great width across post-orbital processes; nasals short; palate much shorter and broader; molar teeth large.

External characters unknown.

Measurements. The type, young adult (probably ♀). Basilar length of Heusel, 205; occipito-nasal length, 187.4; zygomatic breadth, 129.6; mastoid breadth, 101.4; breadth between post-orbital processes, 72.6; inter-orbital breadth, 51.2; palatal length, 114.6; post-palatal length, 91; greatest length of single half of mandible, 164.

Remarks. Mr. Sornborger brought back from Labrador three fine skulls of the Labrador black bear: one from Hopedale, No. 7412, middle-aged adult (probably ♂); one from Maine, a two-thirds grown young; and the type of the form from Okak.

These three skulls show the black bear of the Labrador Peninsula to be easily separable from that of the Canadian regions of eastern North America. It is to be regretted that no skins were procured, as the external characters remain unknown.

The Labrador black bear is common throughout Labrador north to the tree limit. One would expect to find specimens from southwestern Labrador more nearly like true *U. americanus*, if not that form itself.

39. GULO LUSCUS (Linn). American wolverine.

Ursus luscus Linn. *Syst. Nat.* Ed. x, vol. i, p. 47. 1758.

Abundant throughout Labrador, especially northward to Hudson Strait.

Two skulls from Okak in Bangs's collection, obtained by Sornborger. Turner sent one specimen to Washington from Fort Chimo.

40. LUTRA HUDSONICA HUDSONICA Lacépède. Hudsonian otter.

Lutra hudsonica "Lacépède. 1803."

Low states the other to be common throughout the wooded region and to range northward into the semi-barrens. One skull in Bangs's collection from Okak, Sornborger. Turner sent one specimen to Washington from "Forks," Ungava. (Although it appears in the catalogue, it cannot now be found.)

41. MEPHITIS MEPHITICA MEPHITICA (Shaw). Skunk.

Viverra mephitica Shaw. *Museum Leverianum.* p. 172. 1792.

Said by Stearns to be found occasionally on the southern coast of Labrador. I found it common at Lake Edward, Quebec, and it is probable that its range does reach Labrador.

42. MUSTELA AMERICANA Turton. Sable; marten.

Mustela americana. *Turton's Linnæus.* Vol. i, p. 60. 1806.

True *M. americana* probably occurs in southern Labrador, though I have seen no specimens. I took it at Lake Edward, Quebec. The form described below as *M. brumalis* is so different from true *M. americana,* that in the lack of any intermediate specimens I can feel justified only in regarding it as a distinct species. Low's remark, that "the largest and darkest skins are taken along the edge of its northern limits," also inclines me to the belief that two forms are found in Labrador, and that they are specifically distinct.

A complete series of good specimens from points along the whole peninsula would be of the greatest interest, and is one of the things to be hoped for in the future, as marten are common all through the Labrador Peninsula north to the tree limit.

43. MUSTELA BRUMALIS sp. nov. North Labrador marten.

Type. From Okak, Labrador; skull, adult (probably ♂) No. 7417, collection of E. A. and O. Bangs. Obtained by J. D. Sornborger in the summer of 1897 from the Eskimo.

Specific Characters. Skull large, powerful, and heavy; rostrum very short and broad; frontals highly arched; auditory bullæ very large and deep; dentition extremely heavy throughout, the last upper molar in particular being very large; the tooth row a good deal crowded.

External characters unknown.

Measurements. Skull, the type, adult (probably ♂). Basilar length of Heusel, 78.6; zygomatic breadth, 51; mastoid breadth, 38.8; inter-orbital breadth, 19.6; breadth between post-orbital processes, 23.8; width of muzzle across canines, 17.2; greatest length of auditory bulla, 17.2; greatest length of single half of mandible, 58.4; length from front of canine to back of last molar (upper jaw, alveoli), 30.6.

Remarks. Mr. Sornborger brought back from Labrador last summer three skulls of *M. brumalis*, all from Okak. They are unsexed, though all are undoubtedly males. Two are adult and one a young adult, with the nasal sutures plainly visible. When compared with skulls of true *M. americana* from Maine, Quebec, etc., these Labrador skulls show very striking differences; their large size, short, wide rostrums, and enormous

Skulls of M. Brumalis.

teeth at once distinguishing them. Compared with skulls of *M. caurina* the likeness in these respects is greater, but the highly arched frontals and large, deep auditory bullæ of *M. brumalis* are very different from the flattened frontals and small, short, totally differently shaped auditory bullæ of that species.

It is very much to be regretted that there are no skins of *M. brumalis* for comparison, as from Low's casual remark, quoted above, I feel sure there are external characters by which *M. brumalis* can be told from *M. americana*.

44. MUSTELA PENNANTII Erxl. Pennants's marten, Fisher.

Mustela pennantii Erxl. *Syst. An.* p. 479. 1777.

Pennants's marten, according to Low, rarely enters the southwestern limits of Labrador, not occurring east of Mingan nor north of Mistassini.

45. PUTORIUS (LUTREOLA) VISON VISON (Schreber). Little black mink.

Mustela vison Schraeber. *Säugt.* Vol. iii, p. 463. 1778.

Low says the mink is found only in the southern part of Labrador, seldom occurring north of East Main and Hamilton Rivers. I found it very common at Lake Edward, Quebec, but have never seen a Labrador specimen.

46. PUTORIUS (ARCTOGALE) CICOGNANII CICOGNANII (Bonap.). Small brown weasel.

Mustela cicognanii Bonap. *Fauna, Italica, Mamm.* p. 4. 1838.

Reported by Low to be common everywhere south of tree limit.

Goldthwaite took two specimens, ♂ and ♀, at Rigoulette. Turner took one at "Forks," Ungava.

One would expect to find *Putorius cicognanii richardsonii* occurring in the semi-barrens of northern Labrador, but the three specimens referred to above are all true *cicognanii.*

47. VULPES LAGOPUS (Linn). Arctic fox.

Canis lagopus Linn. *Syst. Nat.* Ed. xii, vol. i, p. 59. 1766.

The Arctic fox is abundant in the barren grounds and extends south to about Lake Michikamaw and to Nichicum. Along both coasts it pushes rather farther south; on the Atlantic to Hamilton Inlet, and rarely even to the Strait of Belle Isle; on the coast of James Bay to its southern part.

Two skulls in Bangs's collection from Hebron, obtained by Sornborger.

48. Vulpes pennsylvanica subsp.? Red fox.

Common throughout the whole of Labrador from the St. Lawrence to Hudson Strait.

Six skulls in Bangs's collection, obtained by Sornborger at Hopedale and Okak. One wretched skin in National Museum, Washington, collected at Kokwak River, Ungava, by Turner.

The Labrador red fox is not true *V. pennsylvanica*, but until I have seen material enabling me to study its external characters, I am unwilling to refer it definitely to any form.

49. Canis albus Joseph Sabine. Arctic wolf.

Canis lupus — albus Joseph Sabine. *Franklin's Narrative.* Appendix, p. 655. 1823.

Occasionally taken in northern barren grounds, Low.

50. Canis occidentalis Richardson.[1] Timber wolf.

Canis lupus, occidentalis Richardson. *F. B. A. Mamm.* p. 60. 1829.

According to Low, the timber wolf is now very rare in the southern wooded region, owing to the extermination of the woodland caribou. It is still common in the barrens and semi-barrens of the north.

One skull in Bangs's collection from Hopedale, collected by Sornborger.[2]

51. Lynx canadensis (Geoff.). Canada lynx.

Felis canadensis. "Geoff. *Var. Mus.*"

Common within the wooded area from the Atlantic coast to Hudson Bay, Low.

[1] I use Richardson's name, *Canis occidentalis*, for the timber wolf of eastern North America, not that I feel sure it is the name that will eventually stand for that animal, but in the confused state of the nomenclature of our large wolves I see no other course to follow at present. *Canis griseus* Sabine cannot be used, as it is preoccupied by the *Canis griseus* Boddaert, 1784, one of the synonyms of the gray fox, *Urocyon cinereo-argentatus*.

[2] The Eskimo dog, *Canis familiaris*, var. *borealis* Desmarest, is included by Low in his list. Although in a semi-wild state for a part of the year, the Eskimo dog does not seem to me entitled to a place in the list of the mammals of Labrador.

	Present List.	A. P. Low's List. [In Annual Report, *Geological Survey of Canada*, vol. viii, 1895.]
1.	*Monodon monoceras* Linn.	*Monodon monoceras* Linn.
2.	*Delphinapterus leucas* (Pallas).	*Delphinapterus catodon* Linn.
3.	*Lepus americanus* Erxl.	*Lepus americanus* Erxl.
4.	*Lepus arcticus bangsii* Rhoads.	*Lepus timidus* Linn, var. *arcticus* Leach.
5.	*Erethizon dorsatus* (Linn).	*Erethizon dorsatus* Linn.
6.	*Zapus hudsonius* (Zimmermann).	*Zapus hudsonius* Zimmermann.
7.	*Zapus insignis* Miller.	
8.	*Fiber zibethicus* (Linn).	*Fiber zibethicus* Linn.
9.	*Dicrostonyx hudsonius* (Pallas).	*Cuniculus torquatus* Pallas.
10.	*Synaptomys innuitus* (True).	
11.	*Microtus enixus* Bangs.	*Arvicola riparius* Ord.
12.	*Microtus pennsylvanicus labradorius* Bailey.	
13.	*Evotomys ungava* Bailey.	
14.	*Evotomys proteus* Bangs.	
15.	*Phenacomys latimanus* Merriam.	
16.	*Phenacomys ungava* Merriam.	
17.	*Peromyscus maniculatus* (Wagner).	*Hesperomys leucopus* Rafinesque.
18.	*Castor canadensis* Kuhl.	*Castor fiber* Linn.
19.	*Arctomys monax melanopus* (Kuhl).	*Arctomys monax* Linn.
20.	*Sciurus hudsonicus* Erxl.	*Sciurus hudsonius* Pallas.
21.	*Sciuropterus sabrinus* (Shaw).	*Sciuropterus volucella* Pallas, var. *hudsonius* Gml.
22.	*Sorex personatus* I. Geoff. St. Hilaire.	*Sorex personatus* Geoffrey St. Hilaire.
23.	*Condylura cristata* (Linn).	
24.	*Myotis lucifugus* (Le Conte).	*Vespertilio lucifugus* Le Conte.
25.	*Myotis subulatus* (Say).	*Vespertilio subulatus* Say.

	Ovibus moschatus Zimmermann.
26. *Alce americanus* Jardine.	*Alce americanus* Jardine.
27. *Rangifer caribou* (Gml.).	*Rangifer caribou* Linn.
28. *Rangifer arcticus* (Richardson).	*Rangifer grœnlandicus* Linn.
29. *Rosmarus rosmarus* (Linn).	*Obodœnus rosmarius* Malmgren.
30. *Phoca vitulina* Linn.	*Phoca vitulina* Linn.
31. *Phoca hispida* Schreber.	*Phoca fœtida* Fabricius.
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39. *Gulo luscus* (Linn).	*Gulo luscus* Linn.
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41. *Mephitis mephitica* (Shaw).	*Mephitis mephitica* Shaw.
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44. *Mustela pennantii* Erxl.	*Mustela pennantii* Erxl.
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46. *Putorius cicognanii* (Bonap.).	*Putorius vulgaris* Linn. *Putorius ermineus* Linn.
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49. *Canis albus* Joseph Sabine.	*Canis lupus*, var. *albus*.
50. *Canis occidentalis* Richardson.	*Canis lupus* Linn.
	Canis familiaris Say.
51. *Lynx canadensis* (Geoff.).	*Lynx canadensis* Desmarest.

PRESENT LIST.	A. P. LOW'S LIST. [In Annual Report, *Geological Survey of Canada*, vol. viii, 1895.]
1. *Monodon monoceras* Linn.	*Monodon monoceras* Linn.
2. *Delphinapterus leucas* (Pallas).	*Delphinapterus catodon* Linn.
3. *Lepus americanus* Erxl.	*Lepus americanus* Erxl.
4. *Lepus arcticus bangsii* Rhoads.	*Lepus timidus* Linn, var. *arcticus* Leach.
5. *Erethizon dorsatus* (Linn).	*Erethizon dorsatus* Linn.
6. *Zapus hudsonius* (Zimmermann).	*Zapus hudsonius* Zimmermann.
7. *Zapus insignis* Miller.	
8. *Fiber zibethicus* (Linn).	*Fiber zibethicus* Linn.
9. *Dicrostonyx hudsonius* (Pallas).	*Cuniculus torquatus* Pallas.
10. *Synaptomys innuitus* (True).	
11. *Microtus enixus* Bangs.	*Arvicola riparius* Ord.
12. *Microtus pennsylvanicus labradorius* Bailey.	
13. *Evotomys ungava* Bailey.	
14. *Evotomys proteus* Bangs.	
15. *Phenacomys latimanus* Merriam.	
16. *Phenacomys ungava* Merriam.	
17. *Peromyscus maniculatus* (Wagner).	*Hesperomys leucopus* Rafinesque.
18. *Castor canadensis* Kuhl.	*Castor fiber* Linn.
19. *Arctomys monax melanopus* (Kuhl).	*Arctomys monax* Linn.
20. *Sciurus hudsonicus* Erxl.	*Sciurus hudsonius* Pallas.
21. *Sciuropterus sabrinus* (Shaw).	*Sciuropterus volucella* Pallas, var. *hudsonius* Gml.
22. *Sorex personatus* I. Geoff. St. Hilaire.	*Sorex personatus* Geoffrey St. Hilaire.
23. *Condylura cristata* (Linn).	
24. *Myotis lucifugus* (Le Conte).	*Vespertilio lucifugus* Le Conte.
25. *Myotis subulatus* (Say).	*Vespertilio subulatus* Say.

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47.	*Vulpes lagopus* (Linn).	*Vulpes lagopus* Linn.
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VARIATION IN THE NUMBER OF RAY-FLOWERS IN THE WHITE DAISY.

F. C. LUCAS.

[THE following fragmentary observation of Mr. Lucas is of importance because of its relation to the extended series of enumerations of the ray-flowers of the white daisy (*Chrysanthemum lucanthemum*) of Europe, which has lately been made by Prof. F. Ludwig, of Greiz, and published in the *Botanisches Centralblatt.* Ludwig finds that the commonest number, the mode, is 21. There are, however, several secondary maxima, which with the principal mode constitute the series 8, 13, 21, 34 — the series of Fibonacci. The counts of Mr. Lucas are interesting in that, first, the mode in the number of ray-flowers is different for two localities, and, secondly, while one of these modes (21) falls in the Fibonacci series, the other (22) has no relation to it. The secondary maximum, which in both curves is found at 29, is likewise not in accord with Ludwig's law. These simply made observations, then, raise the questions whether the mode of a varying organ may not vary decidedly in different localities, and whether Ludwig's law will, even with an indefinitely large number of counts, hold for the white daisy as we find it in America. ED.]

During the latter part of my vacation in the summer of 1897, I was in Nova Scotia, and, abundant material being at hand, I thought I would see if I could verify the law of variation in the ray-flowers of the common ox-eye daisy. I managed in the short time at my disposal to count about 500 specimens from the regions of Yarmouth and Grand Pic. I thought to count enough more when I returned to the States to bring up my total to one thousand. I was much surprised to find, however, for reasons which will appear later, that the flowers of the two regions could not be included in one lot. The specimens counted in the States came from Milton and Cambridge, Mass., and were 324 in number.

12 17 22 27 32 37

Fig. 1.

12 17 22 27 32 37

Fig. 2.

No. of Ray Classes.	Nova Scotia. Fig. 1.		Massachusetts. Fig. 2.	
	No. of Indiv.	per 1000.	No. of Indiv.	per 1000.
12	1	2	4	12
13	6	10	2	6
14	5	9	1	3
15	6	10	7	21
16	6	10	8	24
17	5	9	12	37
18	9	17	22	66
19	21	41	32	99
20	41	81	37	114
21	50	98	53	163
22	64	106	36	111
23	52	102	22	66
24	30	59	20	61
25	25	49	13	40
26	25	49	14	43
27	16	31	13	40
28	17	33	5	15
29	31	61	12	37
30	26	51	3	9
31	21	41	5	15
32	19	37	1	3
33	13	26	1	3
34	15	29	—	—
35	2	4	—	—
36	—	—	—	—
37	2	4	—	—
	508		324	

THE DEVELOPMENT OF MANTIS.

T. D. A. COCKERELL.

Dr. D. Sharp, in his admirable work on "Insects" in the *Cambridge Natural History*, vol. v, gives (p. 247) some extraordinary particulars about the development of Mantis, with a figure taken mainly from Dr. Pagenstecher. I have just been observing the facts in the case of a mantis found here, and they do not, in all particulars, agree with Dr. Sharp's account, so that it seems desirable to draw attention to the matter. The eggs removed from the oötheca are elongated and similar to those of Acridiidæ in general appearance ; the egg covering is quite strong but brittle. On removing the young from the oötheca, just before the time of hatching, they are found to be already attached by threads, as has been described by others.

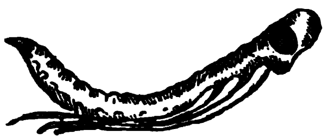

Fig 1.

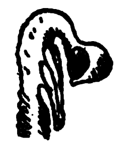

Fig. 2.

Fig. 1 represents one of these young. It is well colored, and all its parts are formed; but, as will be seen from the figure, the head has a peculiar appearance, and the legs are all close together. The general color is pale greenish-yellow, but there are conspicuous rosy dorsal markings ; the internal fluids are bright green. The eyes are at first sage green, but soon after the emergence of the insect they become blackish. Fig. 2 shows the insect after emergence, when it is hanging by its thread. The thorax begins to elongate, with the natural result of forming a hump and bending the head forward. In this way is developed the little mantis, which is much longer than the emerging form, almost wholly by the elongation of the thorax. In my species the insects certainly do not hang for "some days," since examples which hatched out yesterday, at the earliest,

were running about fully formed this morning. I have been quite unable to see any legs such as Pagenstecher describes for the newly hatched young; from the time previous to hatching the normal legs are well formed and there are no others. Nor can I satisfy myself that there is any real ecdysis between the pupa-like form and the active young; at least, all that is shed is apparently a thin egg-membrane, chitinized, however, over the head, forming a sort of cap to protect the bulging anterior end in emergence. Since this structure is developed in the egg, and shed immediately after emergence, should it not be regarded as an oval envelope?

In view of the above observations, it certainly seems desirable that those recorded for *Mantis religiosa* should be confirmed, as I can hardly believe them to be wholly correct. The species observed by me is a Stagmomantis, either *S. carolina* or *S. limbata;* I am not sure which, as both occur in the Mesilla Valley.

MESILLA PARK, NEW MEXICO, U.S.A.,
May 6, 1897.

EDITORIALS.

The Fiftieth Anniversary of the American Association for the Advancement of Science, to be celebrated in Boston in August next, is an occasion when every naturalist in the country will wish to join with his coworkers in other departments of science in celebrating fifty years of scientific activity in America.

Glancing at the history of the association, we find that in 1840 a number of geologists and naturalists of the several state geological and natural history surveys met in Philadelphia for the purpose of discussing the results of their investigations. At this gathering it was determined to organize an Association of Geologists and Naturalists. Edward Hitchcock, State Geologist of Massachusetts and President of Amherst College, was elected president of the association. Annual meetings were held until 1847, when at the meeting held in Boston it was decided to enlarge the scope of the organization so as to include all branches of science, and to reorganize under the name of American Association for the Advancement of Science. Boston, therefore, has the honor of being the birthplace of the present association, although the first regular meeting was held in Philadelphia in 1848. At this meeting Prof. William B. Rogers presided as chairman of the old association, and introduced Prof. W. C. Redfield as the first president of the new association.

The year 1898 marks the fiftieth anniversary of the organization of this association, and the city of Boston was naturally chosen for the celebration of this anniversary. It is the intention of the officers of the several sections to bring out in their programmes, as far as possible, summaries of the progress and achievements of science during the past half century. The Preliminary Programme of Section A, which is already printed, carries out this idea by including "Reports on Recent Progress (accompanied with statements of the 'standing problems'), prepared at the special invitation of the officers and committee, 'with a view to obtaining at this anniversary meeting such a survey of the field as may lead to a possible coöperation of effort.'"

The subject of the address of Prof. Wolcott Gibbs as retiring president is: "Some points in theoretical chemistry."

The vice-presidential addresses will be as follows: Vice-President Barnard before Section A, "Development of astronomical photog-

raphy"; Vice-President Whitman before Section B, "On the perception of light and color"; Vice-President Smith before Section C (to be announced later); Vice-President Cooley before Section D (to be announced later); Vice-President Fairchild before Section E, "Glacial geology in America"; Vice-President Packard before Section F, "A half century of evolution, with special reference to the effects of geological changes on animal life"; Vice-President Farlow before Section G, "The conception of species as effected by recent investigations on fungi"; Vice-President Cattell before Section H, "The advance of psychology"; Vice-President Blue before Section I, "The historic method in economics."

The first step toward extending an invitation to the association to hold its Jubilee Meeting in the city of its birth was taken by the Boston Society of Natural History. The suggestion of this society secured the immediate and hearty coöperation of His Excellency Governor Wolcott and of His Honor Mayor Quincy, and was followed by invitations from the various scientific and educational institutions of Boston and vicinity.

The officers of the Massachusetts Institute of Technology and of the Boston Society of Natural History have generously placed their halls and rooms at the disposal of the association, and thus accommodations will be furnished for all sections and for general sessions in three closely adjoining buildings.

The Local Committee, of which the governor of the Commonwealth is the honorary president, and thirty-one presidents of colleges or scientific institutions are the honorary vice-presidents, includes over three hundred other prominent citizens of Boston and vicinity. This committee has been organized into special committees for the furtherance of the arrangements for the meetings, which are to be carried out in a generous and most cordial manner.

The programme for the week as prepared by the permanent secretary, with the coöperation of the Local Committee, is substantially as follows:

Saturday, August 20. Meeting of the Council.

Monday, August 22. General Session in Huntington Hall at 10 A.M. President Gibbs will call the meeting to order and introduce the president-elect, Prof. F. W. Putnam. Addresses of welcome by the governor, the mayor, and the president of the Institute of Technology. Reply of President Putnam. General business and adjournment of the session for the organization of the sections. In the afternoon the nine vice-presidents will deliver their addresses

before their respective sections. These have been grouped under the hours of 2.30, 3.30, and 4.30, thus making it possible for a member to be present at three of the addresses. In the evening Dr. Gibbs will deliver his address as retiring president; this will be followed by a reception given by the Local Committee to the members and guests of the association.

Tuesday, August 23. This day will be given to meetings of the sections, from 10 A.M. At the close of the afternoon session there will be an excursion to Longwood Hotel, Middlesex Fells. In the evening Dr. Thomas Dwight, at the Harvard Medical School, will lecture on "The variation in human bones, with illustrations from the collection of the Medical School."

Wednesday, August 24. On this day the association will be the guest of the Essex Institute in Salem. In the morning members will leave Boston by train or steamboat for the Salem Willows, where a fish chowder will be served. In the afternoon visits will be made to places of historic and scientific interest. Several other excursions are planned for this day. In the evening illustrated lectures on the Boston Park System and Metropolitan Water Supply will be given in Huntington Hall.

Thursday, August 25. This day and evening will be given to meetings of sections. Late in the afternoon there will be an excursion through the parks to the Arnold Arboretum, with refreshments at Franklin Park. At 9 P.M. the Committee will meet to elect the officers and to determine the place of meeting for the next year.

Friday, August 26. By invitation of the President and Fellows, the association will be the guest of Harvard University. At 10.30 and at 11.30 the officers of the scientific departments of Harvard will give brief addresses explanatory of their respective departments. At noon luncheon will be served in Memorial Hall. The afternoon will be given to visiting the several departments of the University and places of historic interest in Cambridge. At 6 P.M. tea in the Hemenway Gymnasium. At 8 P.M. President Eliot will deliver an address in Sanders Theater.

Saturday, August 27. Concluding General Session at 10 A.M., followed by meetings of the sections. In the afternoon there will be excursions to the Riverside Recreation Grounds, Wellesley College, and by boats on the Charles to Norumbega Tower; also to Lexington and Concord. In the evening the sections will hold their closing sessions.

Monday, August 29. Excursions to the White Mountains, Plymouth,

Provincetown, Woods Holl, Newport, Clinton, and Lawrence Experiment Station, and to other minor points.

During the association week and the days immediately preceding, several affiliated societies will meet in Boston, including the American Forestry Association, Geological Society of America, American Chemical Society, Society for the Promotion of Agricultural Science, Association of Economic Entomologists, Botanical Club of the Association, American Mathematical Society, Society for the Promotion of Engineering Education, American Folk-Lore Society, National Geographic Society, and Botanical Society of America.

Many foreign scientists have been invited to take part in the meeting, and it is hoped that the war will not prevent them from being present.

In his circular letter to members of the association, Professor Putnam, the president-elect, who has been permanent secretary for twenty-five years (and to whom all readers of the *Naturalist* are indebted as one of its founders, and the man who for several years carried the principal burden of its publication), makes the following statement: "There are in every community many men and women engaged in scientific work who should be invited to join the association, and there are many more qualified to become members who would find in the meetings of the association the very incentive they need to develop their love of scientific work. I earnestly appeal to every member to make known the objects and character of the association, and to aid in securing such an increase of membership as shall make this fiftieth anniversary a marked event in the history of the association." Certainly there are many readers of the *Naturalist* who will desire to join the association and take part in this most interesting and important meeting.

Card Bibliographies. — The greatest advance made in recent years in the methods of recording the literature of natural history is the card catalogue issued by the Concilium Bibliographicum of Zürich, Switzerland, of which Dr. H. H. Field is the energetic director. The bureau supplies on cards the titles of the current literature of Zoölogy, Physiology, and Anatomy. The price for the cards is so small that every professional man can afford to purchase this invaluable aid to work, and no library consulted by professional men should be without it. The great advantage of the card system does not appear in the first year of its existence, since bibliographies are also to be had in book form ; but when the literature of the last three, four, or twenty years is all arranged by subjects, and capable

of any arrangement which the individual student may require, the advantage of cards becomes striking. Dr. Field's work is international in its character and receives financial support from societies both in this country and abroad, as well as from the Swiss government. It is under the special care of a committee of the International Zoölogical Congress. The work is, however, so expensive that Dr. Field finds himself embarrassed from lack of funds in his work. It is quite certain that if more subscribers could be obtained the merits of the undertaking would insure the permanency and gradual extension of the work. All professional zoölogists, physiologists, and anatomists are urged to correspond with Dr. Field, with whom arrangements for cards covering a certain group, such as Coleoptera, or a single system of organs, such as the Nervous System, can be made.

Methods in Systematic Work. — In a recent account of some marine annelids of the Pacific coast Prof. H. P. Johnson has based his descriptions and measurements "almost entirely" upon preserved specimens, and states that "there are positive objections in taking measurements from living worms," and that only in respect to color is there "any advantage in drawing up descriptions from living specimens." To be sure, among the higher annelids, the creeping forms, contractions and distortions in preserved material are not so aggravated as in the swimming and tubicolous forms, and in the latter the difficulty of making drawings or even descriptions from the living animals might be advanced as a positive objection. On the other hand, the poses and flexures of the worms in motion, aside from mere color, are often highly characteristic. The author adds, in extenuation of his method, that "nearly all annelid measurements extant have been made upon alcoholic material." This is true, but why? Because the greater part of the annelid literature, the larger works certainly, have not been based upon collections made by the authors themselves, but upon collections gathered by expeditions or accumulated in museums. On the other hand, the supreme value of such works as those of Schmarda and Claparède cannot be denied. The ideal condition would be a combination of the two. The naturalist is most fortunate who has living material for study, and willfully to ignore such study is evil. A habit-picture, if merely a description, does require a skilled artist, and is well worth the pains. It is to be deplored that the good old-fashioned methods of nature study, where descriptions were more than mere formulæ, are falling into disuse.

REVIEWS OF RECENT LITERATURE.

ZOÖLOGY.

Jayne's Skeleton of the Cat.[1] — When Mivart's volume on the cat appeared some eighteen years ago, it was a common opinion that the high-water mark of popular scientific monographing had been nearly if not actually touched, and no one supposed that in less than two decades a work of almost twice the size of Mivart's, and dealing with only the skeleton of the cat, would be placed before the public. This imposing volume, by Dr. Horace Jayne, forms the first part of a series on the complete anatomy of the cat. It consists of an introductory chapter, in which are considered the chief divisions of the skeleton, methods of preparing bones, definitions of terms, etc., followed by an exhaustive description of the skeleton of the cat. This is arranged systematically, each group of bones being first briefly outlined and then the separate bones described in detail. After the anatomy of a bone has been minutely portrayed, there usually follows an account of its nomenclature, determination, articulations, muscular attachments, ossification, variations, and finally its relations to the corresponding human bone. Although the subject-matter of the volume is so systematically arranged that any desired reference may be quickly and easily turned to, a well-devised index of some twenty-five pages has been appended.

The importance of terminology in text-books of this character is well recognized, and in these days of revised nomenclatures one turns to a new anatomy for judgments. Dr. Jayne's book will be gratifying chiefly to the conservatives, for, as a rule, he adheres to the older names good and bad alike. In his choice of general descriptive terms he is not always happy. Thus the system of general terms, proposed in the introduction, included the tautological phrase "lateral side," a misdemeanor which is atoned for by its almost complete omission from the body of the text. Nor is the use of special terms always carried out with success. In the description of the cervical vertebræ, the vertebrarterial canal is variously called the arterial canal, the vertebral canal, the foramen for the vertebral artery, and the canal for vessels, and the only clue which the uninitiated are

[1] Jayne, Horace. *Mammalian Anatomy, a Preparation for Human and Comparative Anatomy.* Pt. i. The Skeleton of the Cat. xix + 816 pp. J. B. Lippincott Co., Philadelphia, 1898.

given as to the synonymy of these expressions is on page 55, where the arterial canal is mentioned in the text, and reference is given to a figure (Fig. 28) in which it is called the vertebral canal. This looseness in the use of technical terms, while not so serious for the advanced student, is confusing to the beginner, and, what is much worse, schools him in methods which are flagrant violations of the principles of scientific description.

Not only is there a regrettable looseness in the use of terms, but the definitions of these terms are also often unsatisfactory. Thus, in commenting on the general axes of the vertebrate body, the author tells us (p. 39) that "lines drawn at right angles to the median plane are transverse lines; lines *in or parallel with the median plane are longitudinal lines*, and lines connecting the back and belly are vertical lines," a lapse in geometry rather than in anatomy. Similar inaccuracies of definition occur also in the body of the text; for instance, on page 46, under the title "Characters Common to all Vertebræ," we are told that "each vertebra, whatever its shape, consists of two essential parts, the ventral cylindrical body or centrum, and the dorsal transverse neural arch," and on page 109 we are further informed that the typical caudal vertebra consists "of little more than an elongated body," and that it has "no neural arch." Instances of this kind lead to the conclusion that Dr. Jayne's forte does not lie in making definitions.

Aside from its defects in terminology, the description of the cat's skeleton is remarkably full and accurate. We have read much of it with a specimen in hand, and have found practically nothing worthy of serious criticism. The only real omission that we have noted is that of the relatively insignificant penis bone. In exhaustiveness this description places the osteology of the cat second only to that of the human being. As the chief object of the book is to give a full description of the cat's skeleton and not to advance a system of terminology or modify the existing ones, we must congratulate the author on his success.

The illustrations accompanying the descriptions form one of the most striking features of the volume. To say that they are numerous would be to understate the truth; they are profuse. In the description of the skull the account of each bone is usually accompanied with one or more outlines of the whole skull, on which are shown in heavy lines the limits of the particular bones considered. This method is also used for the bones of the carpus and tarsus, and as in each case the whole hand or foot is reproduced, the extravagance of

the method becomes obvious, for an outline figure covering something over eight square inches is repeated frequently to show the positions of bones often occupying not over an eighth or even a sixteenth of a square inch of surface. The method is certainly better than that of giving only a single general figure on some remote page, but it seems to us less successful and certainly less economical than that of placing the general figures on a folded sheet which, though attached to the book, may be kept in view while any page is being consulted.

Another feature of the illustrations is their size. Those taken from the cat are said to be magnified twice, except where otherwise stated, a rule for which Fig. 524 is an exception. This double magnification is generally satisfactory, for a smaller cut would usually involve the loss of some important details; but the enlargement of many figures, such as those of the lumbar (Figs. 65, 69) and of the caudal vertebræ (Figs. 79, 81), seems to us uncalled for.

Aside from the remarks on the human skeleton, almost the whole volume is written in the spirit of pure descriptive anatomy, for, although the book purports to be among other things a preparation for comparative anatomy, information of a comparative nature seems almost studiously shunned. Thus, in describing the ossification of the occipital bone, the statement is made that it arises from four parts, but not the least intimation is given that these parts are the real bony elements separate in most vertebrates and fused in the higher mammals to form the occipital bone. Other complex bones, like the innominate, etc., are scarcely better treated. Some idea of the author's conception of comparative anatomy may be gained from the statements on page 596, where the names of the carpal bones are arranged in three columns, according as they are employed by American anatomists, European anatomists, and comparative anatomists; the last, according to their column, have not as yet discovered the pisiform bone. Notwithstanding that the author chooses to ignore the many pertinent and well-established facts of comparative anatomy, he indulges without any apparent reason in a discussion of seventeen pages on the evolution of mammalian teeth, a discussion which presents only one side of an extremely complex question and which in reality is largely made up of quoted extracts from the later writings of the author's celebrated townsman, Professor Cope. Why the teeth rather than other parts should have been taken for comparative treatment is not clear. On the whole, the way in which the author chooses to deal with the comparative side of his subject is perhaps the least satisfactory aspect of the volume.

The intention that the book shall be used by those preparing for medicine has led the author to devote considerable space to the relations of the bones in the human skeleton to those in the cat. In most instances these comparisons are in every way commendable, but in one or two cases they seem to us misleading. The sphenoid bone in man is known to be formed by the fusion of some eight elements, all of which may exist as separate bones in the lower vertebrates. In the cat these sphenoid elements are not united to form a single bone, as in man, but fuse into two distinct groups, the posterior of which usually unites with the occipital bone. The cat, therefore, does not possess a sphenoid bone, though, like many other vertebrates, it has the elements out of which one might have been formed. It is to be regretted that descriptive human anatomy has so biased the author that he has been unable to appreciate this difference, but has ascribed to the cat a sphenoid which he then states is composed of two parts.

Notwithstanding what seem to us the shortcomings of the volume, the substantial body of facts which it contains will insure for it the respect of investigators, and while we do not anticipate its extensive use as a class book, we believe that it will find its way to the bookshelf of every working anatomist and to the laboratory table of many students. We need only add, in conclusion, that the publishers are to be commended for their excellent presswork and binding.

G. H. P.

Rabbit Anatomy.[1] — Dr. F. Clasen, whose article on the muscles of the shoulder and arm of the cat appeared some three years ago, has just published the continuation of his work on the corresponding parts in the rabbit. The article, which is illustrated by some ten clearly drawn figures, gives in a thoroughly satisfactory way the origin, insertion, form, and innervation of the muscles of the shoulder and arm as far as the elbow in the rabbit. It is concluded with a table, showing the innervation of the two dozen muscles described. The author reserved for a later publication the general conclusions to be drawn from his study of the shoulder and arm musculature. To teachers accustomed to use Krause's well-known book on the rabbit this article will be a welcome supplement for the parts under consideration.

G. H. P.

[1] Clasen, F. Die Muskeln und Nerven des proximalen Abschnittes der vorderen Extremität des Kaninchens: Nova Acta. *Abh. der kaiserl. Leop.-Carol. deutschen Akad. der Naturforscher*, Bd. lxix, Nr. 3, 1897.

Stomach Movements.[1] — One of the most interesting papers in the last number of the *American Journal of Physiology* is that by W. B. Cannon on the movements of the stomach studied by Röntgen rays. Animals, chiefly cats, were fed upon food containing a small amount of bismuth subnitrate, which, being opaque to the rays, brings the form of the stomach clearly to view and thus allows the movements of normal digestion to be observed with ease. The cardiac portion of the stomach acts as a reservoir, in which, however, salivary digestion probably goes on. The pyloric portion is the seat of continuous constriction waves, which course from near the middle of the stomach to the pylorus. These thoroughly mix the food with the gastric juice, triturate it, and at intervals discharge some of it into the intestine, this operation being kept up till the stomach is empty. A very remarkable condition observed was that the stomach movements were almost instantly inhibited whenever the cat showed signs of anxiety, rage, or distress — a practical hint as to postprandial occupations.

G. H. P.

Paired Fins of Fishes.[2] — In the last number of the *Jenaische Zeitschrift*, Dr. H. Brans gives an exhaustive account of the innervation of the paired fins of selachians, holocephala, and dipnoi. About half the paper is taken up with detailed anatomical descriptions, the substance of which is clearly summarized in a concluding table. The remainder of the paper is devoted to a discussion of the origin of vertebrate extremities, in which the author defends with some show of reason Gegenbaur's archipterygium theory and attempts to refute the more usually accepted theory of the continuous lateral fin. The paper is refreshing in that its author claims that in the settlement of morphological questions comparative anatomy should have a hearing as well as embryology.

G. H. P.

Anatomy of Salpa.[3] — Dr. M. M. Metcalf has published as a "separate" a paper of some twenty-six pages on the eyes and subneural gland of Salpa. The histology and embryology of the eyes in

[1] Cannon, W. B. The Movements of the Stomach, Studied by Means of the Röntgen Rays. *The American Journal of Physiology*, vol. i, pp. 359, 382, 1898.

[2] Brans, H. Ueber die Innervation der paarigen Extremitäten bei Selachiern, Holocephalen und Dipnoern. Ein Beitrag zur Gliedmassenfrage. *Jenaische Zeitschrift*, Bd. xxxi, pp. 239, 468, 1898.

[3] Metcalf, M. M. The Eyes and Subneural Gland of Salpa. The Friedenwald Co., Baltimore, 1898.

the solitary and chain forms of Cyclosalpa are given in detail, and an account of the subneural gland in this genus is appended. The paper is an abstract of a dissertation accepted at Johns Hopkins University for the degree of doctor of philosophy. G. H. P.

Relationships of American and European Mammalian Faunas. — Mr. A. Smith Woodward concludes a most valuable *résumé* of the history of the mammalian fauna of Europe and America (*Natural Science*, May, 1898) with the following considerations as to the place of origin of the various elements in the two worlds. At the base of the Eocene it is evident that the faunas of the east and the west were essentially identical. As they are traced upwards they gradually diverge.

The first noteworthy difference is the great development of the Condylarthra in America, and the rise in the Eocene of the large specialized Amblypoda, of which only a single genus (Coryphodon) has been found in the corresponding fauna of Europe. On the other hand, the still larger hoofed animals of the sub-order Proboscidea seem to have originated in the Old World, and did not reach America until the late Pliocene.

The Perissodactyla—the tapirs, rhinoceroses, and horses— appear to have advanced on a parallel course on the two continents, though in America both the rhinoceroses and the horses became extinct at the close of the Pliocene, the former without acquiring the characteristic horn.

Among Artiodactyla, both the deer and pigs seem to have been approximately parallel in their development in both continents, only differing in some minor branches, which soon became extinct. The camels, however, are clearly American throughout, only wandering into the Old World by Asia in the Pliocene. It is almost equally probable that the oxen originated in the Old World.

Among Carnivora, the Creodonta are both American and European; but on the former continent they only pass upwards into the dogs (Canidæ), weasels (Mustelidæ), and the aberrant cats of the family Nimravidæ, while in Europe they are succeeded, not merely by these families, but also by the Viverridæ, Hyænidæ, Felidæ, and Ursidæ. The viverroids and hyænas never reached America, but the true cats and bears arrived on that continent at the close of the Pliocene.

Of the Primates, the primitive lemuroids appeared in the Eocene similarly on both continents; but in North America they soon became extinct, while in the Old World they were followed by the true apes, and still have some specialized survivors.

Embryonic Budding in Hymenoptera. — Mr. Paul Marchal has recently published in the *Comptes Rendus* of the French Academy a preliminary account of a peculiar method of a sexual reproduction. The chalcid parasite Encyrtus lays a single egg in each egg of the moth Hyponomeuta. Like other chalcid eggs, this is at first surrounded by a cellular envelope; the cells of this multiply rapidly and develop into a long epithelial tube within the parasitized egg. The egg proper divides, and the divided portions separate, each one giving rise to an embryo, so that from one egg from fifty to one hundred embryos arise, lying like a chain in the epithelial tube, each of which gives rise to an Encyrtus like the parent. The author is at a loss to suggest a parallel to this method of reproduction among the Metazoa. The case of Lumbricus, as first described by Kleinenberg, at once suggests itself; and then there is that interesting case described by Agassiz in his "Methods of Study in Natural History," according to which the egg of our common sea snail Natica undergoes its third segmentation, and then from each of the resulting eight cells an embryo develops. Has any one yet confirmed this observation, or, if it be erroneous, has any one explained how the mistake arose?

The Cyclostome Pronephros. — In spite of the enormous literature on the pronephros, there are yet many points of fundamental importance unsettled. The recent papers of Rabl, van Wijhe, Felix, Field, Semon, and Price show many points of difference and few of agreement. The latest paper to come to our notice is that by S. Hatta (*Annotationes Japonica*, vol. i, 1897), upon the pronephros of the lamprey. Hatta claims that both the pronephric tubules and the pronephric duct arise from the region of the unsegmented mesoderm, but that the tubules at first correspond to the more dorsal segments. At most but six pairs of pronephric tubules are formed, the first and second of these in the segments where the posterior gill-slits later appear. These tubules, together with the sixth, disappear. Hatta regards these tubules as homologous with the Nierencanälchen of Amphioxus.

Marine Character of African Lake Fauna. — Mr. J. E. S. Moore recently read a paper before the Royal Society upon the results of his studies of the invertebrates of Lake Tanganyika, Africa. He points out that the fauna of this lake is strikingly unlike that of the other African lakes, Nyanza, Shirwa, and Kela, and that it has a facies peculiarly marine and of deep-sea forms at that. His conclu-

sion is that the easiest explanation of these facts would be to regard this lake as having been a deep arm of the sea at least as late as tertiary times, and that its animals are the descendants of a former marine fauna. The delicate nature of the medusæ of the lake, and the fact that its molluscs are deep-water forms, renders it impossible that they have migrated into the lake under existing conditions.

The Species of Millepora. — Thirty-nine so-called species of Millepora, the stag-horn coral, have been described from the seas of the world. Dr. Hickson, of Manchester, read a paper at the meeting of the Zoölogical Society of London, on April 5, in which he stated that the characters hitherto used for the discrimination of species have proved of no value, and it is believed that but one species exists, the various forms being due to the conditions under which the individuals lived.

Centrosome in Myzostoma. — Kostanecki has recently investigated the early phenomena of the egg of *Myzostoma glabrum* (*Arch. mikr. Anat.*, Bd. li). The most important statement made is that the centrosomes of the first cleavage spindle arise, as in other Metazoa, from the male centrosome, a result in conflict with Wheeler's previous studies.

Hermaphroditism of Crepidula. — Prof. E. G. Conklin, who has long been studying the embryology of Crepidula, concludes that this genus affords another case of protandric hermaphroditism and of marked sexual dimorphism.

Palæospondylus. — A few years ago Dr. R. H. Traquair described under this name a small fossil from the rocks of Scotland, which he regarded as a fossil cyclostome. Dr. Bashford Dean concluded a little later that a specimen in his possession showed traces of paired fins, a fact which threw doubts upon its cyclostome affinities. Dr. Traquair replied to the effect that the markings around the fossil, regarded by Dr. Dean as indicating the existence of paired fins, were due to inorganic agencies. At the meeting of the Zoölogical Society of London, on April 19, Dr. Dean presented a paper supporting his views, while Mr. A. Smith Woodward, the eminent authority on fossil fishes, stated that he was inclined to agree with Traquair in his interpretations. The question is one of great interest, and the last word has yet to be said upon it.

BOTANY.

The Ninth Report of the Missouri Botanical Garden. — It is doubtful whether the word "report" best describes the annual collection of original papers issued from the Missouri Botanical Garden. It is true each volume is prefaced by a brief statement of the financial condition, chief expenditures, and general progress of the Garden, but the body of the present "report," like most of its predecessors, is made up of articles upon research work, in fact of *acta*, a term for which, unfortunately, the English language possesses no very satisfactory equivalent. The more important events in the development of the Garden, during 1897, have been the erection of a new range of greenhouses; the acquisition of 2½ acres of additional land, and the purchase of the Redfield, Joor, Jermy, and Boehmer & Ludwig herbaria, together making an increment of about 30,000 specimens to the already extensive herbarium of the Garden. A peculiar feature in the report is an attempt to give a money valuation to the specimens in the herbarium, the value fixed upon being 10 cents per mounted sheet. This, it is true, approximates the ordinary commercial rate for recent collections, but in large and well-organized herbaria, in which considerable groups of plants have received expert identification of monographers, and many are, as Dr. Gray used to say, "embalmed in synonymy," it would certainly seem that the value, if given at all, might fairly be placed at a considerably higher figure. The growth of the library of the Garden has been even more remarkable than that of the herbarium, since no less than 7756 books and pamphlets have been secured during 1897.

The principal scientific papers in the report are: "A revision of the American Lemnaceæ occurring north of Mexico" (already noticed in these pages), by C. H. Thompson; "Notes upon *Salix longipes* Shuttl. and its relations to *S. nigra* Marsh.," by Dr. N. M. Glatfelter; "Revision of the genus Capsicum," by H. C. Irish; "List of cryptogams collected in the Bahamas, Jamaica, and Grand Cayman," by Prof. A. S. Hitchcock; "*Agave Washingtonensis* and other Agaves flowering in the Washington Botanical Garden in 1897," by Dr. J. N. Rose; and "The species of Cacti commonly cultivated under the generic name Anhalonium," by C. H. Thompson.

Especially noteworthy among these papers is Mr. Irish's monograph of Capsicum. An intensive examination of this well-known genus (which yields the various forms of red pepper known as

Cayenne, Chilli, Tabasco, etc.) was begun many years ago by Dr. E. Lewis Sturtevant, of Framingham, Mass; but owing to ill-health he was obliged to relinquish the work. Accordingly, with the gift of his noble collection of prelinnæan herbals, he sent to the Missouri Botanical Garden in 1892 his notes upon and specimens of the genus Capsicum. The task of shaping these materials into a final monograph has been a difficult one, and through some changes in the corps of herbarium assistants its completion has met with much delay.

The extreme variability in the forms of Capsicum led even in prelinnæan times to the characterization of a great number of species, and during the last century and a half more than 150 species and botanical varieties have been described and named, to say nothing of numerous lesser variations designated as horticultural forms. However, Mr. Irish is wisely conservative in his botanical treatment, recognizing but two species, *C. annuum* and *C. frutescens*. Of these the former exhibits much the greater variability and in the present treatment is divided into some twelve botanical and fifty-five horticultural varieties, many of which are figured. The extensive bibliography and the complex synonymy of these forms are cited with great fullness and detail. B. L. R.

Sur le genre Simmondsie.[1] — The shrubby monotype *Simmondsia californica* Nutt. has long been placed among the Buxaceæ. It inhabits arid regions in Southern and Lower California, and by the Spaniards is called *jojoba*. Economically it is notable for its large embryos, which, when removed from the seed-coats, are edible and nutritious in the manner of almonds. Without recognizing its identity with Nuttall's Simmondsia, Dr. A. Kellogg once described the plant as a Galphimia, but this was a mere guess at its affinity. Other botanists, who have dealt with its classification, have until now agreed in referring it to the box tribe of the Euphorbiaceæ or to the Buxaceæ, if that group is separated as an independent family. However, on the basis of morphological and anatomical investigations Professor Van Tieghem now expresses the belief that its affinities are rather to be found among the Chenopodiales, and furthermore that it is best regarded as the type of a distinct family, the Simmondsiaceæ, to be placed next the Tetragoniaceæ. The chief reasons assigned for the separation of Simmondsia from the Buxaceæ are the peculiar structure of the stem (in which successive

[1] Van Tieghem, Ph. *Journal de Botanique*, vol. xii, pp. 103–112.

fibro-vascular zones arise from the pericycle), the diœcious flowers, pentamerous calyx, absence of corolla, indefinite stamens, solitary ovules, apical position and caducous character of the stigmas, exalbuminous seeds and accumbent cotyledons. Several of these features, however, do not appear to have in the present case much diagnostic value. For instance, nothing can be argued from the absence of petals, since these members are either lacking or extremely rudimentary in the other Buxaceæ. As to the indefinite stamens, these occur also in Styloceras, which is furthermore subdiœcious. Nevertheless, enough good distinctions remain to show a rather wide gap between Simmondsia and the other genera of the group to which it has long been referred.

The tendency to make new families of divergent or anomalous genera is of late very pronounced. Thus, in the interval between the issue of Engler & Prantl's *Natürlichen Planzenfamilien* and the supplement of the same work, a rather large number of these small and often monotypic "families" have been suggested. The creation of such families, if followed by no rearrangement, is of doubtful practicality, and likely to complicate rather than to clarify classification. It is otherwise, of course, in cases like the present, where a composite group must be divided in order that its parts may be more naturally distributed in relation to allied families.

B. L. R.

Contact Irritability in Hook Climbers.[1] — In this article Dr. Ewart gives an exhaustive account of the phenomena of contact irritability presented by certain tropical hook climbers which he investigated at Buitenzorg. Treub was the first to call attention to the fact that the hooks of certain climbing plants thickened and became stronger when fixed to some support. His work having been mainly morphological, Dr. Ewart has taken up the physiological aspect of the question.

This involved the consideration of the effect of variation in the intensity of the stimulus applied; of the transmission and ultimate effect of such stimuli on the growth of the parts concerned. The stimulus afforded the plant under its natural condition, that brought about by the usual artificial mechanical devices, and, in addition, the stimulation caused by injury, all received attention. The reaction is observable in the inequilateral increase of growth of the hooks,

[1] Ewart, A. J. Contact Irritability. *Ann. du Jard., Bot., de Buitenzorg*, vol. xv, i, pp. 187–242.

and the results are tabulated in measurements of various parts of these organs.

Dr. Ewart finds that in a purely physiological sense a series of connecting forms exists between the simpler forms of climbing hooks as seen in *Uncaria* and the highly specialized tendrils of the *Passiflora* type. The simplest type of all is represented by the hooks in *Cæsalpinia*, *Rubus fruticosa*, etc., where their use in climbing is purely accidental, in consequence of which fact they do not thicken on contact. Next in the series comes *Luvunga*, possessing non-irritable spines and irritable climbing hooks, followed by the type represented by *Uncaria* and *Artrabotrys*, where only the irritable clasping hooks are found. In his work only the last two were experimented with. Next in order come forms like *Roncheria* and *Ancistrocladus*, where, besides the thickening, the sensitive region shows a slightly increased curvature produced by contact alone. Finally, in forms represented by the root tendrils of *Vanilla*, tendrils of *Cucurbita*, *Passiflora*, *Sicyos*, etc., is presented the phenomenon of rapid and, at first, transient curvature by contact alone. In such cases it is the alteration in the turgidity of the parts that effects the change.

Dr. Ewart goes on to say that no hard and fast line can be drawn between a mere contact and a pressure stimulus. Irritable hooks are adapted to respond to pressure more readily than do tendrils, the latter being affected to a greater degree by contact. In certain cases at least, pressure and traction stimulate cambial activity corresponding to the mechanical requirements of such cases. Contact stimuli appear to affect only the outer layer of cells directly, the curvature resulting being due to the transmission of an impulse. The weak stimulus afforded by injury to the parts concerned is probably to be explained by the normal increase of activity, a kind of tissue pyrexia, which is known to follow wounding.

In cases where the curvature is slowly produced, as in Strychnos, the change cannot be due to any alteration of turgidity but to an heterauxesis in the cambial growth.

Irritable hooks and tendrils, regarded in analogy with other irritable organs, are parts which respond as a whole when any portion of them is stimulated, the result varying, of course, with the point of application and the nature of the exciting stimulus. In conclusion, the author says that the irritation caused by contact stimulus, in the strict sense, is limited almost wholly to the concave surfaces of the hooks. When the pressure is increased to bring about an internal mechanical strain, a response is eventually to be noticed, but

not so quickly nor to such an extent as under normal conditions of contact.

The plants experimented with chiefly were: *Uncaria sclerophylla*, *Ancistrocladus Vahlii*, *Roncheria Griffithiana*, *Artrabotrys Blumei*, *Strychnos monospermum*, *S. laurina*, *Amphilobium mutsii*, *Bauhinia tomentosa*, *Dalbergia linga*, and *Vanilla aromatica*.

H. M. R.

Apogamy in Ferns.[1] — A considerable series of cultures under varying conditions show that some, at least, of the conditions which induce apogamic development in fern prothalli are a deprivation of water sufficient to prevent the possibility of fertilization and the action of direct sunlight. Different degrees of apogamy are possible, from a cylindrical process still bearing sexual organs arising from the apex of the prothallus, to the condition where this process gives rise directly to the vegetative bud of the sporophyte.

While the authors admit that, with certain assumptions, the theory of antithetic alternation, as advanced by Bower, affords a satisfactory explanation of the relation of the gametophyte to the sporophyte generation, they are inclined to favor more the idea of homologous alternation, namely, that the sporophyte arose gradually from modifications of individuals resembling the sexual plant, and is not from a mere elaboration of the zygote. The line of evidence offered bears on the assuming of a terrestrial habitat by originally aquatic plants, whereby these plants, in adapting themselves to dryer surroundings, are forced to develop in the line of the production of dry reproductive cells (spores) rather than the more sensitive sexual organs. Hence the increase in size and importance of the spore-bearing plant, which eventually, by its own mass of vegetation, would afford shade, and consequently the conditions more suitable for the persistence of the primitive moisture-loving sexual stage.

The authors conclude by saying that the question is still an open one and must remain so until more decisive evidence is brought forward by which either the theory of homologous alternation or that of antithetic alternation can be shown to be untenable.

H. M. R.

A New Method for Preserving and Fixing Fresh-water Algæ.[2] — This fixing agent consists of equal volumes of formalin, pyrolignic acid, and methyl alcohol. The algæ are drained as far as is possible, without injury to them, from the water in which they grow, and

[1] Lang, W. H., and Clark, G. H. On Apogamy and the Development of Sporangia upon Fern Prothalli, *Bot. Centralblatt*, Bd. lxxiv, Nr. 3, p. 72.

[2] Pfeiffer, Oesterreicher. *Bot. Zeit.*, Bd. xlviii, Hefte 2 und 3, 1898.

placed directly in a quantity of the solution, which should be at least equal in volume to the mass of algæ taken. They will keep in this way indefinitely. When it is desired to use the material it may be washed in several changes of water to which some antiseptic agent has been added or in a 10% solution of glycerine. For sectioning in paraffin the specimens are treated in the ordinary way with various grades of alcohol. The author also recommends certain special carmine stains.

H. M. R.

Sunstroke and Bacteria. — From *Natural Science* (May, 1898), we learn that Dr. Lugui Sambon claims to have shown that under the term sunstroke are included two entirely different things: that many reported cases are due only to syncope, and when these are eliminated there remains a thermic fever to be attributed to a specific organism. He shows that the disease possesses definite symptoms and has a definite geographical distribution. That heat is not the cause is evidenced by the fact that people in certain regions, or under artificial conditions, work in temperatures far higher than exist in places where sunstroke frequently occurs, without suffering from the disease. Thus, true sunstroke is absent from the dry plains of Colorado, as well as from the high central plateau of India, while it is common in the moister climate and lower temperatures of the Mississippi Valley and the Atlantic coast of America, as well as on the low-lying plain of the Ganges. It also frequently occurs with great fatality in hospitals. He compares the bacterium with that of tetanus, and considers that it lives in the soil and is carried into the system with dust, and there forms the toxic poison, which is the real cause of death.

PETROGRAPHY.

The Igneous Rocks of the Boston Basin are again the subject of petrographic study. White[1] finds among them granites, diorites, quartz-porphyries, felsites, melaphyre, and diabases. The last two-named rocks occur as dikes. The melaphyre is an altered basalt, constituting a flow which is amygdaloidal at its upper surface. The quartz-porphyries appear to be regarded as a peripheral phase of granite, and the felsites as a surface facies of the same rock. Both

[1] *Proc. Bost. Soc. of Nat. Hist.*, vol. xxviii, p. 117.

the porphyry and the felsite are called aporhyolites by the author, though he does not attempt to prove that their present features are due to the devitrification of an ancient glass. The granites comprise four types, distinguished as dioritic and hornblendic granites, granitite and hornblendic diorite. Nearly all these rocks had already been described by earlier writers. White adds a few points of interest concerning them.

The Eruptive Rocks of Mexico. — Harrington [1] gives a *résumé* of an article by Ordoñez, in which are described briefly the eruptive rocks of Mexico. The precretaceous eruptives are principally granites, associated with sedimentary rocks, and sometimes with younger rhyolites and andesites. With the cretaceous age began a great series of eruptions whose products were granites, granulites, syenites, diorites and diabases, and the "greenstones" characteristic of the mining districts. Among these latter are andesites, green dacites, trachytes, rhyolites, labradorites, and basalts. The rhyolites of Chichindaro, of San Ildefonso, of Tula, of Hidalgo, and a few other places are sphemlitic. Some of the modern volcanoes erupt andesites, and others trachytes. Many of the trachytes contain olivine, and occasionally these rocks grade into typical basalts. Labradorites are also common lavas. They differ from basalts in containing but little, if any, olivine.

The Gneisses of Anglesey, England.[2] — The gneissic series of Anglesey, England, comprises plutonic rocks that have suffered crushing and shearing subsequent to their consolidation. The banded gneisses were formed from a complex of diorite and felsite, or from felsite whose secondary structure has been accentuated by the infiltration of dark-colored minerals along the cleavage planes. The normal gneisses of the district were formed from granite, diorite, or felsite. The hälleflinta, so frequently mentioned in the literature of the district, is a partially altered felsite.

Syenite Porphyries of the Lake Champlain District. — In the pre-Potsdam area of Clinton County, N. Y., Cushing [3] finds a series of dikes, composed of a basic rock which is classed as syenite-porphyry. This rock consists of a microperthitic intergrowth of albite and orthoclase, biotite, magnetite, hematite, hornblende, quartz, albite,

[1] *Journ. of Geol.*, vol. v, p. 466.
[2] *Quar. Journ. of Geol. Soc.*, vol. liii, p. 349, 1897.
[3] *Bull. of Geol. Soc. of Amer.*, vol. ix, p. 239.

orthoclase, microcline, apatite, and sphene, with secondary chlorite, calcite, muscovite, epidote, and hematite. The microperthite and usually the biotite are in phenocrysts, the remainder of the minerals constituting a groundmass with the trachytic structure. The most basic of the dikes has the following composition:

SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO_2	CaO	MgO	K_2O	Na_2O	P_2O_5	Cl	F	Loss	Tot.
52.53	18.31	.34	6.43	.15	3.15	1.82	6.47	7.26	1.59	.40	.32	1.16	= 99.93

The magma from which the dike material was produced belongs to the foyaite type. The most acid of the dikes are syenite porphyries; the most basic are types of a rock that would seem to be too basic to be included in this group.

A Study in Weathering. — An interesting study of weathering has recently been made by Smyth,[1] his subject being the dike of alnoite at Manheim, N. Y. The fresh rock, which is black, consists largely of biotite, and serpentine derived from olivine, and of some magnetite, apatite, perofskite, and secondary calcite. Its weathered product is a soft golden-brown clay-like mixture of bleached mica, magnetite, perofskite, probably apatite, and some very fine-grained material of uncertain nature.

Analyses of the fresh and the weathered rock calculated to 100 per cent, and the proportion of loss for each constituent are:

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	K_2O	Na_2O	Ign	Tot.
Fresh	35.51	2.27	6.14	8.59	5.64	20.55	7.46	2.90	.71	10.23	100
Weathered	33.40	2.93	7.95	16.86	1.49	13.54	5.30	.29	.23	18.01	100
Loss	27.31	.00			3.70	48.97	45.10	92.27	74.97	.00	

About 27 per cent of the original rock has been removed by solution, causing its complete disintegration, and yet a great portion of its original components can be detected in its weathered product.

Notes. — Hopkins[2] describes the brownstones of Pennsylvania from the economic standpoint. He gives a brief account of the microscopic structure of thin sections of the product of each of the working quarries in the state.

Although the liebenerite-porphyry of Predazzo has long been regarded as a rock derived from some nepheline-bearing porphyry, no rock containing nepheline had been found in the Predazzo district

[1] Smyth, Jr., C. H. *Bull. Geol. Soc. of Amer.*, vol. ix, p. 257.

[2] Appendix to *Ann. Rep. Penn. State College*, for 1896.

up to within a few years past. Osann and Hlawatsch[1] now report the existence of blocks of a porphyritic rock in the Viezzena valley, in whose hand-specimens phenocrysts of sanidine are plainly evident. In the thin section, phenocrysts of orthoclase, microcline, plagioclase, pyroxene, hornblende, mica, and garnet are in a holocrystalline groundmass composed of feldspars, nepheline, sodalite, and various secondary products. The authors call the rock a nepheline-syenite porphyry. It differs from the original of the liebenerite-porphyry in containing no nepheline phenocrysts.

On the contact of a hauynophyre dike with limestone near Horberich, in the Kaiserstuhl, Brauns[2] finds a contact rock that is very unusual in composition. It consists of melanite, calcite, augite, gehlenite, hauyn, apatite, and mica. The gehlenite is in well-defined crystals, intergrown with the calcite, garnet, and the hauyn. The hauyn, melanite, and augite are thought to have been derived from the volcanic rock, and the gehlenite to be a result of the contact action.

A few volcanic rocks from the Baluchistan-Afghanistan boundary have been submitted to McMahon[3] for study. He finds among them andesites, basalts, a granite, a quartz-syenite, various acid lavas, pumice, tuffs, and a few sedimentary rocks. The phenocrysts in the andesite are oligoclase and andesine, the former predominating. Three of the andesites contain anthophyllite; and one, an augite hornblende-andesite, contains phenocrysts of olivine.

The lava[4] of Mt. Edgecombe, Krusov Island, Alaska, is an hypersthene-andesite composed of two generations each of plagioclase, hypersthene, augite, and magnetite.

Cross[5] reports the existence of another volcanic rock containing analcite. The rocks form a small outcrop in "The Basin," about twelve miles west of Cripple Creek, Colo. It is a basalt, composed of the usual constituents of basalt, to which are added large and small colorless grains of analcite. Analysis of the separated analcite yielded:

SiO_2	Al_2O_3	$Fe_2O_3.FeO$	CaO	SrO	MgO	K_2O	Na_2O	K_2O	Tot.
51.24	24.06	1.20	1.62	.06	.33	1.25	11.61	9.09	= 100.40

The analysis of the rock shows it to be very closely allied to the monchiquites of Rosenbusch.

[1] *Min. u. Petrog. Mitth.*, vol. xvii, p. 556.
[2] *Bericht. Oberhess. Ges. f. Natur. u. Heilk.*, 1898.
[3] *Quar. Journ. of Geol. Soc.*, p. 289, August, 1897.
[4] Cushing, H. P. *Amer. Geol.*, p. 156, September, 1897.
[5] *Journ. of Geol.*, vol. v, p. 684, 1897.

GEOLOGY.

Lavas and Soils of the Hawaiian Islands.[1] — The rocks of the Hawaiian Islands, with the exception of limited accumulations of coral and calcareous sands and a "remarkable felspathic andesite" reported by Dana, are basaltic lavas. The surface lavas have been changed to soil by two processes: first, by the action of heated vapors charged with sulphuric acid; and, second, by the normal processes of weathering.

The vapors now escaping through fissures over large areas within the crater of Kilauea at times contain as high as 4.92 per cent of sulphuric acid, and ranging in temperature from the lowest to the last point of condensation. In many instances the walls of the fissures, through which the acid-laden steam escapes, are luminous with heat at night. Marked chemical changes in the rocks are in process about these solfataras, and similar alterations have been observed at a distance from recent volcanic activity, where "poison soils" prevent the growth of vegetation.

The sulphurous vapors, acting on the heated basalt, disintegrates it, changing the lime into gypsum, the aluminum and alkalies into alum, and the iron into the ferrous sulphate. These products separate out in distinct masses, and impart to the soil various colors and properties. The iron, upon exposure to the air, changes to the hydrous ferric oxide, and gives rise to laterites.

Geologically, the soils are classified into three types:

1. *Dark Red Soils:* Those derived from normal basalt by simple weathering in a hot, dry climate, — the red color being imparted by the anhydrous ferric oxide. They are the most fertile soils.

2. *Yellow and Light Red Soils:* Those derived from lavas, which were first altered by the action of sulphurous vapors, and subjected to subsequent weathering in a humid climate. The color is due to the hydrated ferric oxide. As a type they are generally lacking in fertility.

3. *Sedimentary Soils:* Those produced by disintegration of lava at high elevations, and then subsequently removed by rain-wash and streams to lower and flatter lands.

When compared with the glacial soils of America, the soils of the

[1] Maxwell, Walter. Lavas and Soils of the Hawaiian Islands. Investigations of the Hawaiian Experiment Station and Laboratories [Established by the Hawaiian Sugar Planters Association], pp. 1–186, map and four plates. Honolulu, 1898.

Hawaiian Islands show some remarkable peculiarities. They are of recent origin, are strongly basic in character, being composed largely of silicates soluble in acids. The leaching processes, to which they have been subjected, has removed in great measure the acidic constituents. The glacial soils of America, on the other hand, are derived from ancient rocks, and are composed largely of silicates insoluble in acids. The basic constituents have been largely removed by prolonged weathering, and the soils differ markedly from the rocks from which they were derived.

The soils of the Hawaiian Islands are classified by Maxwell, according to the climatic conditions under which they originated, as follows:

1. *Upland Soils:* Those formed under low temperatures and large rainfall.

2. *Lowland Soils:* Those formed under high temperature and small rainfall.

From analysis made on a large number of samples of these soils, it appears that those of the first class contain a large per cent of organic matter and nitrogen, while the elements of plant food have been largely removed by leaching; and that the soils of the second class have a low content of organic matter and nitrogen, and a high percentage of plant-food elements in an available state. These differences are due to the fact that the lowland soils receive the surface waters from the upland soils.

In determining the availability of the food supply of the soils, the author assumed that the amount removed by cropping added to the amount carried away by drainage waters equaled the total available supply. From a large number of analyses made of the waters and of agricultural products, it was found that the amount of the various elements carried away from the soil by the drainage waters equaled the amount of similar elements removed by cropping. By a series of experiments to ascertain the action of organic acids of various degrees of concentration on the different soil constituents, it was found that aspartic acid dissolved the essential plant-food materials in approximately the same proportions as they were found in the drainage waters. Furthermore, it was found that a one-per-cent solution of this acid removed the same amounts of these materials in twenty-four hours as ten crops of sugar cane; hence it was concluded that one-tenth of the amount of lime, phosphoric acid, and potash removed from a soil by a one-per-cent solution of aspartic acid in twenty-four hours is the available supply of that particular soil.

A special feature of this highly instructive report is the large number of analyses of rocks, soils, and water which it contains. It is unfortunate, however, that a more definite discrimination is not made between observed facts and hypotheses. An analytical table of contents and an index, both of which are absent, would have greatly enhanced the value of the report.

SCIENTIFIC NEWS.

The tenth congress of Russian naturalists and physicians takes place this year at Kieff, August 21–30, under the presidency of Prof. J. Rachmaninoff.

Dr. Franz Ritter von Hauer, for several years intendant of the Hof Museum of Vienna, has been retired.

The British Association for the Advancement of Science will hold its meeting for 1899 at Dover, from September 13–20, probably under the presidency of Prof. Michael Foster. The French Association will meet at about the same time on the opposite side of the channel, at Boulogne, so that visits can be exchanged between the two associations. The place of meeting in 1900 has not yet been decided; possibly it will be at Bradford. In 1901 the meeting will be held in Glasgow.

Dr. William T. Brigham has been appointed director of the Berenice Panahi Bishop Museum at Honolulu, H. I. A large addition is to be made to the museum building.

The sixty-ninth anniversary meeting of the Zoölogical Society of London was held April 11, 1898. From the reports we extract the following items. At the close of the year the number of fellows was 3158; the income for the year was nearly £29,000; and the library contained over 20,000 volumes. Three new buildings were opened to the public. The society met with a serious loss in the death of A. D. Bartlett, for 38 years superintendent of the gardens. His son, Clarence Bartlett, was appointed to the position. The visitors to the garden in 1897 were 717,755, and the number of animals on exhibition was 2585, about half of these being birds. The election of officers for the ensuing year resulted as follows: President, Sir W. H. Flower; secretary, P. L. Sclater; treasurer, Chas. Drummond; members of council, F. E. Beddard, W. T. Blanford, R. Lydekker, H. Saunders, and C. S. Tomes.

The German Society of Anatomists held its twelfth annual meeting at Kiel, April 17–20, 1898. Among the papers read were the following: Pfitzner, on brachyphalangy and related questions; Barfourth, artificial production of spina bifida in Amphibian larvæ; Unna, the

fat of dermal glands; van Wijhe, the contribution of the ectoderm to the pronephric duct; Rabl, the non-contribution of the ectoderm to the pronephric duct; Bethe, primitive fibrillæ in the ganglion cells and nerve fibres of vertebrates and invertebrates; H. Virchow, surface views of selachian embryos and the region of mesoderm formation; Kopsch, experimental researches on the primitive streak of the chick — similar developmental forms in vertebrates and invertebrates; Reinke, direct cell division and degeneration of the nucleus in liver cells; Meves, spermatogenesis in mammals; Osarva, position of Hatteria in the system; Lenhossek, new centrosomal discoveries; van der Stricht, nucleus of Balbiani; Rabl, anatomy and structure of the lens; Mollier, mechanics of the shoulder girdle; Kolster, Mauthner's fibres in teleosts; Kölliker, dilator pupillæ in white rabbits — primitive fat organ in young mammals — striped muscle in the ligamentum-uteri steres — structure of the ovary in the horse; Gaupp, primordial cranium in Lacerta agilis; Braus, extremities of selachians; Ravn, allantoic stalk of the chick; Klaatsch, tentacle apparatus of Amphioxus; Graf Spee, model of the youngest-known human embryo; Mitrophanow, gastrulation in amniotes; Broman, development of the ossicula auditus in man; Märtens, development of the larynx in the anura; Kallius, development of the larynx in man; Maurer, derivatives of the gill slits in lizards; Grönroos, primary germ layers in Salamandra; Benda, genesis of the spiral filament in the mammalian spermatozoön. The only American to join the society this year was Dr. R. G. Harrison, of Baltimore. The meeting next year will be held in Tübingen, at Whitsuntide.

Recent appointments: Rudolf Beyer, honorary professor of botany in Berlin. — Dr. Arthur Bornträger, director of the agricultural station in Palermo. — Dr. Emil Böse, of Karlsruhe, government geologist of Mexico. — Dr. Friedrich Moritz Brauer, director of the zoölogical collections in the Vienna Hof Museum. — Dr. Alessandro Coggi, of Bologna, professor of zoölogy, comparative anatomy, and physiology in the University of Perugia. — Dr. Giovanni Battista Condorelli, professor of natural science in the technical school at Gaeta, Italy. — Dr. Hanson Kelly Corning, extraordinary professor of anatomy in the University of Bern. — Pierre Fauvel, professor of zoölogy in the University of Angers, France. — Dr. Adriano Fiori, privat docent in botany in the University of Padua. — Dr. Bela Haller, professor extraordinarius of zoölogy in the University of Heidelberg. — Dr. Franz Hoffmann, privat docent for physiology in the University of

Leipzig. — Ludwig Kathariner, professor of zoölogy and comparative anatomy in the University of Freiburg, Switzerland. — Dr. F. L. Kitchen, paleontologist to the geological survey of Great Britain. — Oreste Mattivolo, professor of botany in the Instituto di Studi Superior in Florence. — Dr. Aladár Richter, privat docent for vegetable anatomy in the University of Budapest. — Dr. Domenico Sangiorgi, assistant in the geological cabinet of the University of Parma. — Dr. G. Adolf Sauer, extraordinary professor of geology in the University of Heidelberg. — Dr. Paul Schiemenz, director of the biological and fishery investigation station "Muggelsee," near Berlin. — Dr. J. L. C. Schroeder van der Kolk, professor of mineralogy in the Polytechnicum at Delft, Holland. — Dr. Eugenio Serra, assistant in the botanical garden at Palermo. — Dr. Franz Steindacher, intendant of the Natural History Museum in Vienna. — Dr. Johannes Thiele, of Strasburg, assistant in the zoölogical collections of the Agricultural School at Berlin. — Dr. A. Weberbauer, privat docent for botany in the University of Breslau.

Recent deaths: José d'Anchietá, zoölogist in Angola, Sept. 14, 1897. — Frederick Charles Aplin, ornithologist in Bodicote, England, aged 43 years. — Alphonse Briart, geologist at Mariemont, Belgium, March 15, aged 73. — Dr. Max Dahmen, bacteriologist, in Krefeld, Germany. — George Christopher Dennis, dipterologist, in York, England, December 22, aged 70 years. — Franz Fiala, botanist and archæologist, curator of the ethnological collections of the Museum of Bosnia-Herzegorina, at Sarajevo, January 28, aged 36. — Dr. K. B. Jacob Forssell, lichenologist, at Karlstad, Sweden, February 11. — Dr. Samuel Gordon, president of the Royal Zoölogical Society of Dublin. — Lieut. Charles Cooper King, geologist, in Camberley, Surrey, England, January 16, aged 55. — E. J. S. Linnarsson, botanist, in Sköfde, Sweden. — Emmanuel Martin, lepidopterologist, at Creil, France. — John Carrick Moore, geologist, in London, February 10, aged 94. — Alfred Monod, cryptogamic botanist, at Neuilly, near Paris, aged 61. — Dr. Guiseppe Palma, zoölogist, in Naples, January 18. — A. J. Horace Pelletier, student of injurious insects in Madon, France. — John Robert Streatham Hunter-Selkirk, geologist and antiquary at Braidwood, Scotland, March 23, aged 62. — Thomas James Stoller, geologist, at Evesham, England.

PUBLICATIONS RECEIVED.

British Museum: List of the Types and Figured Specimens of Fossil Cephalopoda, by J. C. Crick. London, 1898. 103 pp., 8vo. — Cope, E. D.: Syllabus of Lectures on the Vertebrates, with an introduction by Henry Fairfield Osborn. Philadelphia, University of Pennsylvania, 1898. $1.00. — Lange, D.: Handbook of Nature Study for Teachers and Pupils in Elementary Schools. Macmillan Co., 1898. xv–329 pp., 8vo. 60 wdcts. $1.00. — Løvendal, E. A.: De Danske Barkbiller (Scolytidæ et Platypodidæ Danicæ) og deres betydning for Skov-og Havebruget. — Kjøbenhavn: Det Schulotheske Forlag, 1898. 212 pp., 4to, 89 wdcts., 5 plates.

Gage, S. H.: The Life History of the Toad, *Teacher's Leaflets*, No. 9, April, 1898. — Washburn, F. L.: Preliminary Report upon the Introduction of the Eastern Oyster to the Oregon Coast. 1898. 4 pp.

Annales del Museo Nacional de Montevideo. Tome ii, Fasc. viii, 1898. — *Bulletin Buffalo Society of Natural Sciences*. Vol. v, No. 5, 1897; Vol. vi, No. 1, 1898. — *Geographical Journal*. Vol. xi, No. 6, June. — *Knowledge*. Vol. xxi, No. 152, June. — *Linnean Society of New South Wales*. Abstract of Proceedings, April 27, 1898. — *Missouri State Horticultural Society*. Fortieth Annual Report. Jefferson, 1898. — *Modern Medicine*. Vol. vii, No. 5, May. — *Proceedings Natural Science Association of Staten Island*. Vol. vi, No. 17, May. — *Revue Scientifique*. Ser. 4, Tome ix, Nos. 22, 23, May and June. — *University of Wyoming*. Experiment Station. Bull. No. 36, April. — *Zoölogical Society of Philadelphia*. Twenty-sixth Annual Report.

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DENTITION OF DEVONIAN PTYCTODONTIDÆ.

C. R. EASTMAN.

(*Continued from page 488.*)

PALÆOMYLUS Woodward (1891).

This genus at present includes the forms described by Newberry as *Rhynchodus frangens* (the type species), *R. crassus*, and *R. greenei*, the first two being found in the Corniferous limestone of Ohio, and the last-named in the Hamilton of Wisconsin.

The special characteristics of this genus, as recognized by Woodward,[1] are as follows: it has a relatively very broad symphysial surface, a triturating oral surface, and a single indefinite tritoral area. From Ptyctodus it is distinguished by having punctate instead of laminated tritors, and the knife-edge of Rhynchodus is replaced in this genus by a broad, uneven, grinding surface. Yet the three types approximate one another through intimate specific gradations. For example, *R. secans* presents the same general form externally as Palæomylus, and between the lower dental plates of *Palæomylus crassus* and *Ptyctodus ferox* in the adult stage there is even greater resem-

[1] *Catalogue Fossil Fishes British Museum*, Pt. ii, p. 38. 1891.

blance. Thus, while there is a general homogeneity of type in Ptyctodont dentition, transitional stages are to be observed in its different expressions.

Palæomylus frangens and *P. crassus* are sufficiently well known through Newberry's figures and descriptions. With *P. greenei*, however, the case is not so fortunate. It has not been hitherto illustrated, and the original description is very brief. As stated by Newberry, it resembles the type species (*P. frangens*), but differs in being narrower vertically, and longer and much thicker at the anterior border. No distinctions are pointed out between upper and lower dental plates.

For further information with regard to *P. greenei* we have to thank Messrs. Teller and Monroe, of Milwaukee, who have kindly supplied all the material in their possession. Of this, the most remarkable specimen — and, we may safely say, one of the most important examples of Ptyctodont dentition yet discovered — is that photographed on the accompanying plate (Fig. 48). It is rivaled only by the specimen of *Rhynchodus secans* described by Newberry, already referred to, in which four teeth were found associated in a group; and the two taken together prove beyond a doubt that the dentition consisted of a single pair of dental plates in both upper and lower jaws. The present specimen was obtained by Mr. Teller in the vicinity of Milwaukee, and is preserved in his private collection.

The teeth are imbedded in a block of limestone measuring 35 cm. in its greatest length, which coincides with the longitudinal axis of the jaws. The illustration may be most conveniently examined by turning the page sideways, with the bottom on the left, and top on the right-hand side of the observer. Oriented in this position, the two lower dental plates will be found on the right-hand side of the figure, in advance of the upper pair; the left upper dental plate is immediately above the right upper, and the left lower above the right lower. All plates have the external surface exposed, with the exception of the right upper, which is broken through obliquely. The inner side is seen near the anterior beak, but farther back it is beveled down through its entire thickness, leaving only an impression of its outer surface on the matrix. Still it shows

the anterior margin and boundary of the triturating surface very fairly; much more so than its fellow, just above, which is the poorest preserved of all.

There is really less difference in the form of the lower dental

FIG. 48. — *Palaeomylus greenei* Newb. Group of four naturally associated dental plates. Teeth of the lower jaw at top, and teeth of the upper jaw at bottom of the figure. Those belonging to the left side of the mouth are on the left, and those belonging to the right side are on the right of the figure. $\times \frac{1}{2}$.

plates than might be inferred from the photograph, owing to perspective effects due to the curved surface of the left lower

tooth. The outlines are preserved nearly intact as far as the extreme antero-superior portion, including the beaks, where there is a slight deficiency. The fracture being an uneven one at this point, and likely to present a misleading appearance, a strip was filled in with plaster up to a level with the external surface as far as the impression of bone substance was preserved on the underlying matrix, but no further. The original boundary was probably not far distant from the dotted line shown in the figure, which has been restored from the outlines of other specimens.

The differences between upper and lower dental plates are not nearly so decided as in either Ptyctodus or Rhynchodus, yet, such as they are, leave no reasonable doubt as to the position occupied by the several teeth in the mouth. The lower dental plates have a more pronounced anterior beak, and are also deeper vertically than the upper pair; and the triturating surface is more uneven. The outline of the latter is sinuous, there being an anterior and a posterior depression, separated by a median elevation; and there are corresponding, although gentler, undulations to match in the margin of the upper dental plates. The opposing outlines coincide most nearly with one another when we make the upper beaks protrude slightly in advance of the lower, exactly as was done in the case of *Rhynchodus secans*. But there is no evidence that the beaks of the lower jaw closed outside the upper dental plates, as in Ptyctodus. On the contrary, appearances indicate that the two jaws came into direct opposition with their triturating surfaces, the same as molar teeth. There is a reverse slope to the grinding surface in both jaws; the anterior depression has a decided slope downward and inward, and the posterior depression an equally pronounced one downward and outward. The grinding surface has an average width of about 1.5 cm., and extends from the beaks as far back as the supero-posterior angle, or where it meets the perfectly straight line forming the posterior margin.

There is a peculiar appearance about the beak of the left upper dental plate which deserves notice, although it challenges explanation. Owing to its faulty state of preservation, no very satisfactory conclusions can be formed as to its nature or

relationships, and the structure is all but obliterated in the half-tone reproduction. This much, however, we are warranted in saying: the extreme tip of the beak has been broken, and the bony substance about it extensively worn away, but traces remain of a thin bony splint or prolongation, somewhat triangular in outline, attached to, and extending in front of, the beak. The ossification is apparently continuous with that of the dental plate itself, yet has not nearly the thickness of the symphysial surface, being seemingly confined to the inner face thereof. Theoretical objections certainly will not allow us to conceive of the existence of an anterior azygous tooth, nothing of the sort being known to occur in this family; nor can the structure justly be called adventitious, since one of Mr. Monroe's specimens presents a similar, yet equally baffling appearance. The only plausible conjecture we can form regarding it is that, owing to the large size of the dental plates, some other besides merely cartilaginous means was required to strengthen their union at the symphysis, and this was supplied by an ossification arising from the inner side of the dental plates, forming a sort of bony suture. Mention is made of this anomaly in the hope that future discoveries may lead to its adequate explanation.

P. predator sp. nov. (Fig. 43). — The type specimen shown in the foregoing figure (p. 483) is unique. It forms a part of the Schultze Collection belonging to the Museum of Comparative Zoology, and was found in the Devonian limestone near Gerolstein, in the Eifel District. It is of no little interest to note that the three Ptyctodont genera, although represented by vicarious species, should thus occur together in homotaxial deposits of such widely separated regions as Central Europe and the Mississippi Valley.

Unfortunately, the present solitary specimen is not very well preserved, but still enough remains to show its general form and relationships. The part exposed to view is the anterior portion, happily with the beak intact, of the right lower dental plate. The inner surface is concealed by the matrix, and, being partly abraded, it is not easy to determine the original thickness of the tooth. Evidently the triturating surface was wide, rela-

tively, since it has a present width of 1 cm. as far as it is preserved back of the beak. The anterior margin is still about 1.5 cm. in thickness, but how much more has been abraded can only be surmised. This is enough, however, to show that the form does not belong to either Ptyctodus or Rhynchodus, although it resembles the latter in contour; hence, we have no recourse but to admit it as a new species of Palæomylus. The transition to Rhynchodus, brought about through thickening of the symphysial region and development of a broad triturating surface, evidently took place through the species described above as *R. major* and *R. rostratus*.

ASSOCIATED ICHTHYODORULITES.

Rohon,[1] in his paper on Ptyctodus, mentions the occurrence in the Russian Devonian of dorsal fin-spines belonging to the so-called "Chimæroid type of ichthyodorulites," as defined by Jaekel.[2] As no other form with which the remains can be theoretically associated is present in the same horizon, Rohon suggests that both dentition and defenses may have belonged to Ptyctodus. The Russian spines are bilaterally symmetrical, triangular in section, slightly curved backward, and are ornamented with numerous small tubercles, more or less regularly arranged. The posterior face is concave, and bears a double series of small denticles.

The style of ornamentation of these spines is remarkable, and we are at once struck with the coincidence that in the Hamilton limestone of Milwaukee ichthyodorulites should be found which have a similar tuberculated ornament. Several very choice examples have been obtained by Messrs. Teller and Monroe, one of the most perfect being that reproduced in Fig. 49, the property of Mr. Teller.

This spine has a very graceful curvature, and is of comparatively large size, the length of an arc joining the extremities

[1] Rohon, J. V. Beitrag zur Kenntnis der Gattung Ptyctodus, *Verhandl. mineral. Gesellsch. St. Petersburg*, vol. xxxiii, pp. 1–16, 1895.

[2] Jaekel, O. Ueber fossile Ichthyodoruliten, *Sitzungsber. Gesellsch. naturforsch. Freunde Berlin*, No. 7, p. 123, 1890.

on the anterior margin being 20 cm. The width where it is broken off below, which is not far distant from the beginning of the exserted portion, is 5.5 cm., and the maximum thickness at this point is 5.5 mm. The spine is extremely compressed laterally, both sides being almost flat. There is no strongly marked anterior keel. The posterior face is slightly sulcated, and each side of the sulcus is set with closely approximated tubercles of somewhat larger size than those occurring elsewhere. The bottom of the sulcus is traversed by a faint longitudinal ridge, triangular in section.

The individual stamp imparted to this spine by its flattened, arcuate shape is heightened by its peculiar ornamentation. The lateral faces are beset with numerous small tubercles not having a very definite arrangement, but in some specimens showing a tendency to become parallel to the anterior and posterior margins. One of Mr. Monroe's spines has the tubercles disposed more numerously along a series of parallel grooves, situated some distance apart, the whole presenting a more or less concentric appearance, and indicating successive growth stages in the development of the organ. The appearances indicate that the inserted portion tapered gradually toward the base, but this region itself has not been recognized on any of the specimens thus far examined. Most of the tubercles have been worn down smooth to their bases, or are evenly rounded on top, but a few retain traces of a fine original stellation. One or two spines, instead of

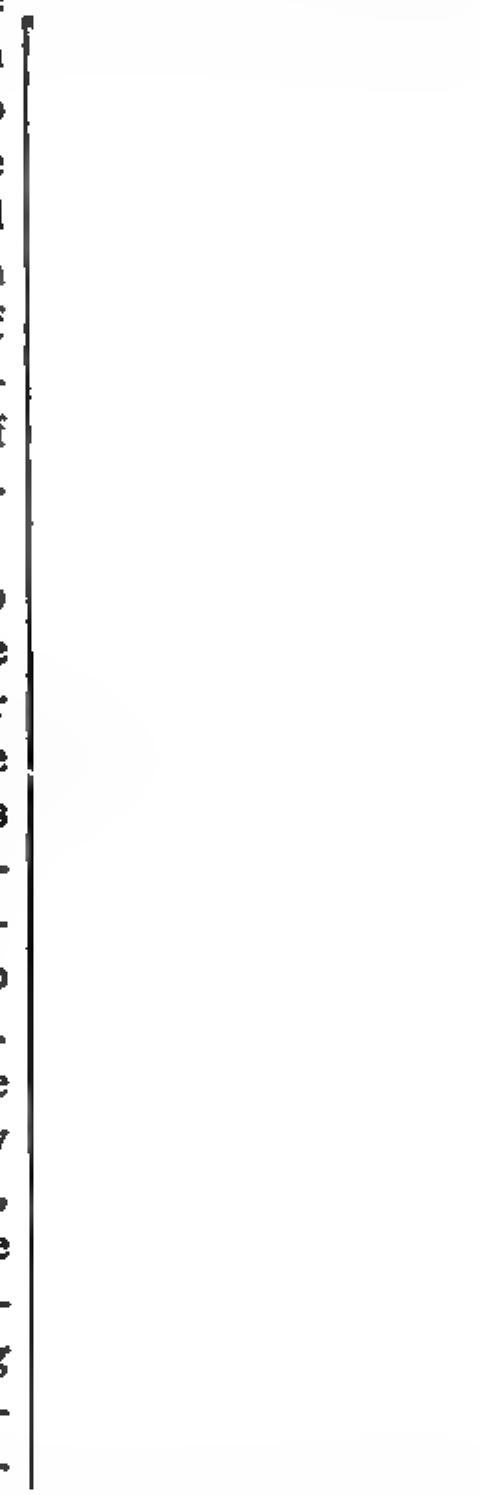

FIG. 49. — *Phlyctænacanthus telleri* sp. nov. Lateral aspect of exserted portion of spine (left face) × ½.

having the anterior margin uniformly curved, show a slight angulation at the region of maximum width, in that the spine tapers gradually from this point in both directions, distally and proximally.

Obviously these spines, differing as markedly as they do from the majority of Palæozoic ichthyodorulites, cannot be included under any known genus or species. We therefore propose the new genus *Phlyctænacanthus* for their reception, and have pleasure in naming the species *P. telleri* in honor of the veteran and indefatigable collector, Mr. Edgar E. Teller. Regarding their affinities, we can only suggest that they may have pertained to Palæomylus. Their large size precludes an association with either Rhynchodus or Ptyctodus; and Cladodus, the only other Elasmobranch known to occur in the Wisconsin Hamilton, was in all probability a spineless shark. On the supposition that these were the spines of *Ptyctodus ferox*, then we ought by good rights to have found similar fossils in the State Quarry fish bed, where there is such a wonderful concentration of Ptyctodus remains. But such spines as have been recovered from the Iowa locality are very different from *Phlyctænacanthus*. The latter are thus definitely excluded from all known genera occurring at Milwaukee, except Palæomylus. But as we know nothing, for instance, of the dentition with which *Heteracanthus politus* was associated, so, too, there is as much likelihood of *P. telleri* belonging to some unknown Elasmobranch genus as to Palæomylus. But as to the relative probability of one of these "genera" of Milwaukee ichthyodorulites belonging to the *Ptyctodontidæ*, the evidence of the tuberculated Russian fin-spines would go to show that *Phlyctænacanthus* is the likelier of the two to have its position established here.

(2) *Belemnacanthus giganteus* gen. et sp. nov. (Fig. 50). — This is the last form to claim our attention, and we notice it here more on account of its accompanying Ptyctodont remains in the Eifel Devonian than with the intention of suggesting possible Chimæroid affinities. In fact, we are inclined to suspect that it may have been of Ostracoderm rather than of Elasmobranch nature. But without entering into the question of its

systematic position further than this, we are content for the present with a portrayal of its general appearance, as shown in the adjoining views, supplemented by the following notes.

This unique and in many ways remarkable spine, which must be regarded as the type of a new species and genus, belongs to

FIG. 90. — *Belemnacanthus giganteus* sp. nov. *A*, *C*, lateral, and *B*, inferior aspects of spine. × ½

the Schultze Collection, and was found in the Devonian, near Kerpen, in the Eifel District. It is extremely massive and even cumbersome, being solid throughout and of formidable proportions. The terminal portion of the spine is preserved for a distance of 27 cm., and the impression of it is continued for 10 cm. further, on an adherent piece of matrix. The section forms

an equilateral triangle, but the side corresponding to the posterior face in other forms is deeply excavated, the depth of the wedge-shaped cavity amounting to almost half the height of the triangle. In the view given of this side (Fig. 50, *B*), an attempt is made to show the change of slope and median groove at the bottom of the cavity. The surface of the latter is smooth throughout, and the appearances are unmistakable that it either contained soft parts or was attached to them during life. Such could hardly have been the case, however, if the spine stood erect and free from the body of the animal, but would necessarily happen were we to suppose it imbedded lengthwise in the flesh. That it actually was so imbedded appears the more probable when we consider the external aspect. Parallel markings are seen along the border on the lateral faces which apparently indicate the limits of integumentary covering; above these markings the sharp angle of the wedge protruded free as a cutwater, and probably served also as an offensive weapon; below them the bone sank beneath the skin, and was firmly secured by muscles attached to the channeled face. The latter, in the position suggested, would be ***inferior*** instead of posterior; the smaller, pointed end would be ***posterior*** instead of distal; and the larger, heavier end would be ***anterior*** instead of proximal or inserted.

Not only are the mechanical difficulties much lessened, of supporting free from the body an organ of such size and weight as this, according to the interpretation just outlined, but its plausibility is strengthened by the analogy of Edestus, with which it agrees in having no medullary canal. There is no doubt that the simpler types of Edestus (*E. heinrichsi*) were principally imbedded in the integument, so that only the row of denticles protruded. Bashford Dean,[1] in a very luminous paper on this genus, concludes as follows regarding the origin of the structure: "In the present case the evidence may be accepted as conclusive that a spine-like organ had its origin as a metameral structure whose basal portion lay within the integument, and traversed longitudinally a number (seven at least) of

[1] *Trans. N. Y. Acad. Sci.*, vol. xvi, p. 68, 1897. *Cf.* also *Fishes, Living and Fossil*, pp. 28–30, 1896.

body segments; and that from this condition arose a more or less typical spine shaft, thick at one end and pointed at the other, with indications that its decurved character was accompanied by a firmer insertion of the proximal end, and the evasion of a pointed tip." The stages of differentiation passed through by this genus are clearly depicted by Dr. Dean. We cannot well dissent from his view that the segmental structure observed in all species of Edestus is evidence of a primitive condition, and yet Belemnacanthus, a much earlier form, shows no trace of metamerism. Obviously, the two genera represent very different modes of origin of dermal spines. That either of them occupied a cephalic position, as suggested by Dr. Dean for Edestus, seems to the present writer improbable on account of their large size, a likelier position being somewhere along the middle of the back. Newberry's idea as to Edestus was that the spines were situated "in the position of the second dorsal fin on the back or tail of a Plagiostome fish."

The light-colored area at the posterior or pointed end of Belemnacanthus (Fig. 50, *A*, *C*) has been injured somewhat by atmospheric erosion, but still permits the course of the vascular canals to be seen. These run essentially parallel to the ornamental markings on the lateral faces, and prove that growth took place by additions to the posterior end. The markings referred to are in the nature of superficial pittings and furrows, the latter being sometimes continuous and bifurcating, or again short and interrupted. The dotted outline along the crest indicates the position of a thin piece of bone that, having been accidentally broken off from here, was used for sectioning. Nothing very conclusive was gained by this operation, however. The projecting portion of matrix at the top of Fig. 50, *A*, *C*, preserves an impression of the base of the spine as far as it extends. The lower margin being evenly arched throughout its extent of 37 cm., and the summit also as far as it is preserved, we note in this another point of resemblance to Edestus. In conclusion, it may be worth while to record that the largest Arthrodires yet obtained from the Eifel Devonian are *Aspidichthys ingens* v. Koenen; *Anomalichthys scaber* v. Koenen; and *Dinichthys eifeliensis* Kayser; and the largest Elasmobranch the

above-described *Palæomylus predator.* None of these are at all comparable, however, with the gigantic proportions indicated by Belemnacanthus.

ON THE RELATIONS OF THE DEVONIAN FISH-FAUNA OF MILWAUKEE.

Although fish remains are not at all plentiful near Milwaukee, yet the working of the Hydraulic Cement quarries within five miles of the city has enabled collectors to bring together a considerable variety of chordate fossils during the course of time. Only three forms from this locality were known to Newberry when writing his Monograph in 1889. These were *Rhynchodus excavatus*, *Palæomylus greenei*, and *Heteracanthus politus*. Besides the forms made known in the present paper, *Dinichthys pustulosus* was described last year from material that has long been preserved in the Museum of Comparative Zoology. In addition, a few unrecorded and several new species have been obtained by Messrs. Teller, Monroe, and Slocum, making a total representation of at least fifteen species. Among the new species are a tuberculated Titanichthys, plates of Sphenophorus which prove this little-known genus to be an Arthrodire, teeth of Cladodus with curved crown and strong lateral denticles, beautiful large scales of Holoptychius, and a number of dermal ossifications that are undoubtedly of Chimæroid nature. One of the latter bears some resemblance to Myriacanthus. Some detached Ptyctodus tritors are indistinguishable from *P. calceolus*, and one of the Heteracanthus spines seems to be identical with *H. uddeni* Lindahl.

Without question, the most interesting of all these remains, scientifically, is *Dinichthys pustulosus*. The meager material upon which it was founded is now increased by several more or less perfect crania, half a dozen dorso-median plates, the antero- and postero-dorso-laterals, the clavicular (which has the flat outer surface tuberculated), and one of the shear teeth. Unfortunately, the mandibles have thus far escaped detection. The writer's prediction, based upon the peculiar ornamentation of this species, that it would one day prove to be a very primitive

species of Dinichthys, is abundantly verified by the new discoveries, since a more ideal connecting link between Coccosteus and Dinichthys could hardly be imagined. Intermediate characters are most strikingly exemplified by the cranial sutures, sensory canals, and form of the dorso-median plate. A more detailed account of its organization will be presented later. Our purpose now is to call attention chiefly to the facts of its distribution, along with the accompanying Ptyctodont remains.

In the first place, we note that *Dinichthys pustulosus, Heteracanthus uddeni*, and probably *Ptyctodus calceolus* all occur together in the Hamilton of Milwaukee, the State Quarry fish-bed of Johnson County, Iowa, and in the vicinity of Buffalo, Iowa, and Rock Island, Illinois. The Rock Island section has lately been worked up in considerable detail by J. A. Udden,[1] who distinguishes thirteen different beds. Beds Nos. 2, 3, and 4, of his published section, contain the assemblage of fish remains now under discussion, but Ptyctodus also extends upward into Nos. 5 and 9. No. 2 corresponds to the Gyroceras beds of Calvin and Barris, No. 3 to the lower part of the Cedar Valley limestone, and No. 4 to its upper part. Professor Udden has traced out the subdivisions of the fish-bearing beds with great care, and has very kindly submitted the following table for publication at the writer's request, by means of which any one can readily orient himself when collecting in the field.

Descriptive Table of Part of the Section of Devonian Rocks exposed near Rock Island, Illinois.

No. 4 (= Upper Part of Cedar Valley Limestone).

(*b*) A slightly argillaceous bluish limestone filled with fragments of Crinoid stems, locally changing into a white compact limestone, from 6 to 10 feet in thickness. *Megistocrinus latus* Hall and *Striatopora rugosa* Hall almost invariably occur near the base of this division. Transition to the coral-bearing beds above always abrupt and conspicuous.

(*a*) An argillaceous bluish limestone weathering to a dirty yellow. Thickness from 15 to perhaps over 20 feet. Principal fossils are: *Aulopora* sp.; *Monticulipora* sp.; *Streptelasma rectum* Hall; *Atrypa aspera* Schloth.; *Spirifer pennatus* Hall; *S. asper* Hall; *Chonetes pusillum* Hall; *Strophodonta demissa* Conrad; *S. perplana* Conrad; *Orthis iowensis* Hall; *Cyrtina hamiltonensis* Hall; *Goniatites* sp.; *Phacops* sp.; *Heteracanthus uddeni* Lindahl; *Dinichthys* fragments.

[1] *Journ. Cincinnati Soc. Nat. Hist.*, vol. xix, No. 3, pp. 93–95, 1897.

No. 3 (= Lower Part of Cedar Valley Limestone).

(*f*) A layer of calcareous shale or clay, 6 inches thick, containing mostly Brachiopods and Bryozoa.

(*e*) A bed of olive-colored limestone, 2 feet in thickness, rich in fossils, especially Brachiopods, such as *Spirifer pennatus* H.; *S. asper* H.; *Chonetes pusillum* H.; *Strophodonta demissa* Conr.; *S. perplana* Conr.; *Discina* sp. A branching *Monticulipora* generally present about the middle of this bed.

(*d*) A layer of greenish calcareous shale, 6 inches thick, with fossils like those in the ledge below. *Strophodonta perplana* Conr. more abundant.

(*c*) A ledge of limestone, about 16 inches in thickness, of a dull dove color, fine and massive below, almost a shell breccia above. Rich in Brachiopods, such as *Spirifer asper* H.; *S. pennatus* H.; *Atrypa aspera* S.; *Orthis iowensis* H.; *O. vanuxemi* H.; *O. suborbicularis* H.; *Strophodonta demissa* Conr.; *S. perplana* Conr.; *S. nacrea* H.; and *Chonetes pusillum* H.

(*b*) A layer of greenish calcareous shale, 6 inches in thickness, containing mostly Brachiopods like those above.

(*a*) A bed of limestone, 2 feet thick, consisting below of a gray compact rock not dissimilar from No. 2 (*d*); above, it becomes slightly laminated and more fossiliferous. Brachiopods predominate above, corals below. A seam in which fossils are etched and partially dissolved separates this bed from the ledge beneath.

No. 2 (= Gyroceras Beds of Calvin).

(*d*) A ledge of limestone, about 2 feet thick, gray, compact, and strong, the upper part often marked with yellowish or brownish blotches. Principal fossils are: *Stromatopora* sp.; *Favosites alpenensis* Winch.; *F. placenta* Rom.; *Acervularia davidsoni* E. and H.; *Phillipsastræa gigas* Owen; *Crepidophyllum archiaci* Bill.; *Cystiphyllum americanum* E. and H.; *C. sulcatum* Bill.; *Atrypa aspera* S.; and *Spirifer*. Also *Dinichthys pustulosus* Eastm. and *Ptyctodus calceolus* N. and W.

(*c*) A thin layer of limestone, only a few inches in thickness, not always separated from the next above; frequently containing thin seams of clay. *Phillipsastræa* and *Stromatopora* are quite abundant.

(*b*) A ledge of gray compact limestone, about 3 feet thick, invariably containing *Phillipsastræa* and *Crepidophyllum* near the top. Besides having most of the fossils found in the ledge below, it contains: *Chonophyllum* sp.; two or three species of *Cystiphyllum*; one of *Alveolites* of fine, dense structure and spheroidal form; several species of Gastropods and Trilobites; *Phragmoceras*; and *Ptyctodus* tritors.

(*a*) A ledge about 2 feet thick, consisting of a strong, finely granular, and compact gray limestone, with a slight tinge of dusky straw color, occasionally divided by two seams near the middle. Principal fossils are: several species of *Favosites*, *Acervularia*, and other Cyathophylloids; *Stromatopora*; *Spirifer subundifera* M. and W.; *Atrypa reticularis* L. (often with well-preserved spiralia).

From the above it will be seen that the pisciferous beds near Rock Island lie within the equivalent of the Cedar Valley

limestone, with Ptyctodus extending both above and below this level. The State Quarry fish-bed is held by Professor Calvin [1] to represent a later horizon than the Cedar Valley limestone, its anomalous relations leading him to the conclusion "that it was deposited unconformably upon the Cedar Valley limestone after the lapse of a considerable erosion period." The evidence of invertebrate remains indicates that "the relations of the State Quarry limestone are with the Upper and not with the Middle Devonian, as is the case with the Cedar Valley beds." Certainly the vertebrate fauna occurring here is unparalleled elsewhere in the Devonian, but in the assemblage we note the same species of Ptyctodus and Dinichthys as are found at Milwaukee and Rock Island, and probably also Heteracanthus.

Where, now, shall the Milwaukee horizon be placed in the series? The strata here are divisible into two formations, the lowermost being the fish-bearing cement rock, and the uppermost a soft shale apparently destitute of vertebrate remains. Dr. Stuart Weller,[2] who has made a study of the invertebrates, finds that those from the lower formation are apparently most closely related to the typical eastern Hamilton fauna, as represented in New York state, although there are a few forms which seem to represent the Iowa faunas. The upper formation has an abundant and well-preserved fauna, very different from that below. It is not the New York Hamilton fauna, but appears to be intimately related to some of the Iowa Devonian assemblages. With these generalizations vertebrate evidence stands in substantial agreement. Through Rhynchodus, Palæomylus, and primitive Dinichthyids, the hydraulic limestone fauna is related to that of the eastern province, dating back even to the Corniferous of Ohio. The Chimæroids give it a stamp of antiquity, suggesting that a westward migration took place during the early part of the Devonian as far as Wisconsin, but not crossing the Mississippi Valley until the Middle Devonian. The Milwaukee beds show the first traces of encroachment from the east, the Rock Island locality a somewhat later, and the State Quarry limestone the last of all, with its horde of Upper

[1] *Ann. Rep. Iowa Geol. Survey*, vol. vii, pp. 78, 79, 1897.
[2] *Ann. N. Y. Acad. Sci.*, vol. xi, p. 117, 1898.

Devonian lung-fishes. By this time the gigantic Chimæroids (Palæomylus, *Ptyctodus ferox*, Phlyctænacanthus, etc.) had disappeared; the ubiquitous *Ptyctodus calceolus*, it is true, persisted for a while through sheer force of numbers, but after the State Quarry epoch is met with no more. Cladodonts seem to have had a continuous existence throughout this period, appearing first in the Lower Devonian of Campbellton, New Brunswick (Protodus, Doliodus, etc.), but they do not appear to have migrated west of Wisconsin until the Carboniferous. They did not fairly enjoy their ascendency until after the lung-fishes had suffered a decline.

THE WINGS OF INSECTS.

J. H. COMSTOCK AND J. G. NEEDHAM.

CHAPTER III (*Concluded*).

XII. THE VENATION OF THE WINGS OF COLEOPTERA.

The determination of the homology of the wing-veins of the Coleoptera is a difficult problem, owing to the greatly modified structure of the wings. Not only do the wings differ in structure from those of any other order of insects, but the two pairs of wings are modified in different ways. The fore wings, or elytra, have lost their flight-function, and have become thickened protective organs; while the hind wings are, in most cases, transversely folded, which has resulted in a great modification of the courses of the veins and in the formation of secondary vein-like thickenings of the wing.

So different is the structure of the elytra from that usually characteristic of wings that Meinert [1] was led to believe that they were not wings, but greatly enlarged paraptera of the mesothorax; and unfortunately this view was adopted by the senior writer in his *Manual for the Study of Insects.* We have, therefore, two questions before us: first, Are the elytra modified wings, or not? and, second, What are the homologies of the wing-veins?

The reasons in support of Meinert's view are the following: the difference in the structure of elytra from that of wings; the fact that in the Lepidoptera the paraptera of the mesothorax often bear a striking resemblance to elytra (this can be well seen by removing the scales from the paraptera, or patagia, as they are termed, of a sphinx moth); and the fact that in many Coleoptera (*e.g.*, *Dytiscus*) what appear to be rudiments of the fore wings exist beneath the elytra.

The argument based on the thickened structure of the elytra loses its force when we consider the more or less elytra-like

[1] Meinert, F. *Entomologisk Tidskrift*, p. 168. 1880.

wings of many other insects (Heteroptera, certain Blattidæ, *et al.*); and it probably would not have been seriously urged but for the presence of the so-called rudimentary wings beneath the elytra of certain beetles.

When, however, the supposed rudimentary wings are examined, they are found to correspond in structure and position to the alulæ of the wings of other insects. The most conclusive evidence of this correspondence is the fact that they are margined by the cord-like structure which has been termed the

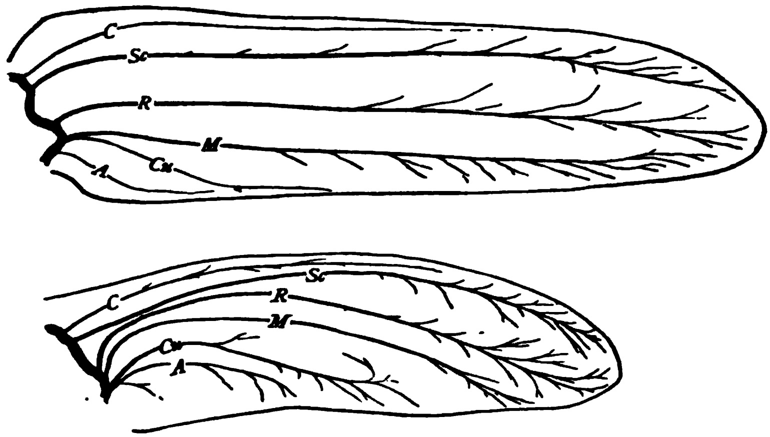

FIG. 50. — The tracheation of the wings of a cerambycid pupa.

spring-vein. This arises from the caudal border of the scutellum, and is a distinctive characteristic of this portion of the wing. The presence of these membranes beneath the elytra, therefore, merely indicates that if the elytra are modified wings they do not correspond to entire wings but to wings minus the alulæ.

When the elytra of a pupa of a beetle are examined, they are found to be traversed by several, usually five or six, longitudinal tracheæ. Although these tracheæ may give rise to a greater or less number of smaller tracheæ, there is nothing in the branching of them, in any of the forms that have as yet fallen under our observation, that corresponds with the branching of the tracheæ in our hypothetical type. But as this is almost as true of the hind wings, it has little bearing on the question of

the homology of the elytra. We are forced to conclude that in this order the wings are so modified that the typical branching of the veins is lost. We have examined, however, a comparatively small series of coleopterous pupæ; and it is quite possible that generalized forms may yet be found in which the typical branching of the veins is preserved.

We refer to the veins instead of to the tracheæ in this connection, as some observations that we have made indicate that in the Coleoptera as in the Hymenoptera the venation of the

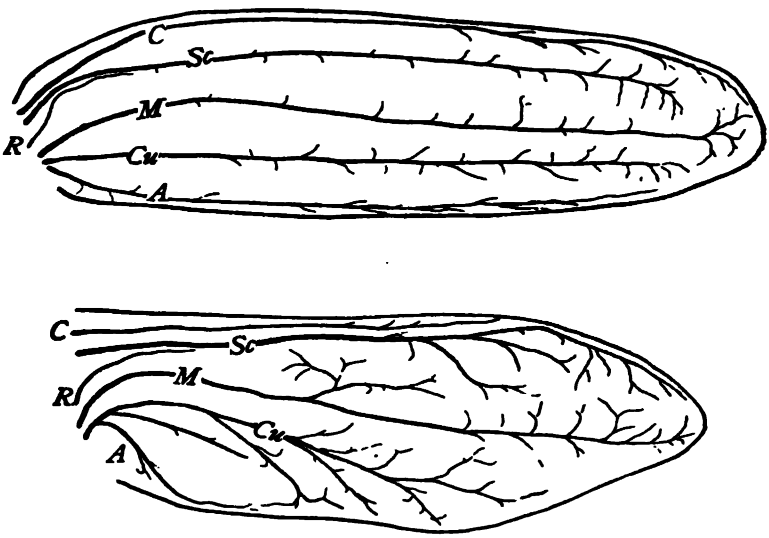

FIG. 51. — The tracheation of the wings of a cerambycid pupa.

wings precede their tracheation, and that the courses of the main tracheæ are determined by the courses of the preëxisting veins.

Returning to the question of the homology of the elytra, the most conclusive evidence that we have found is the fact that a very close correspondence exists between the tracheation of the elytra and that of the hind wings. And what is especially striking is that similar modifications occur in the two pairs of organs.

The accompanying figures of the elytra and wings of two cerambycid pupæ illustrate this point. And the lettering of

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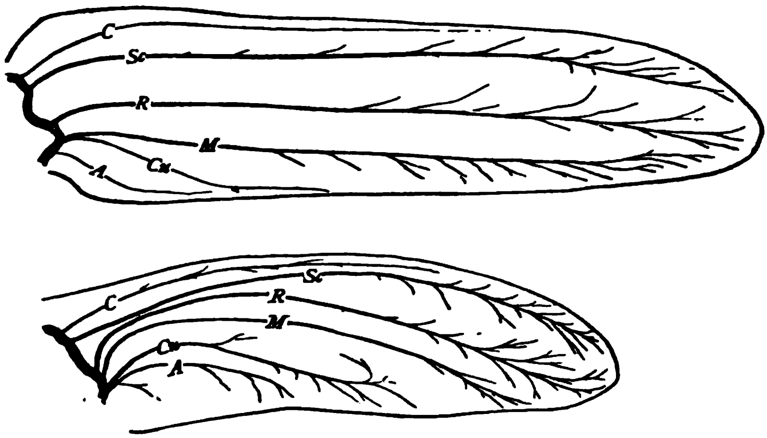

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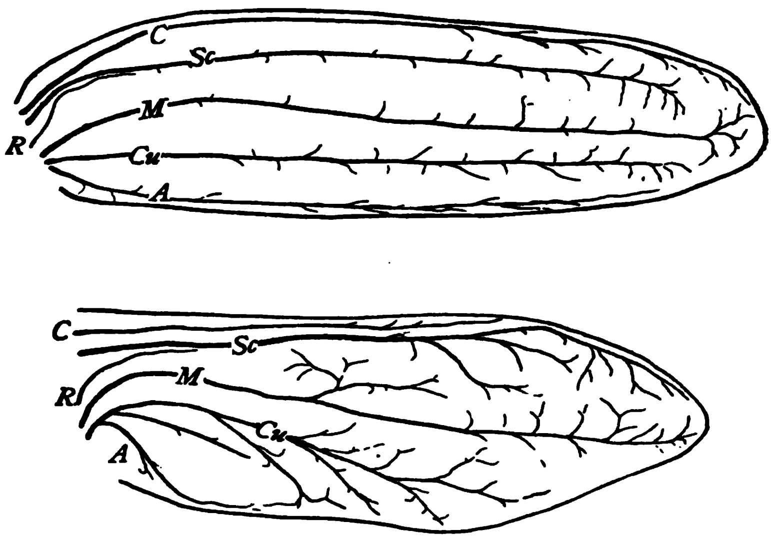

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these figures will serve to show our conclusions regarding the homologies of the tracheæ.

In the species represented by Fig. 50, the radial trachea is the most prominent one in both elytra and hind wings. On the other hand, in the species represented by Fig. 51, the radial trachea is reduced in both elytra and hind wings to a mere rudiment. If the elytra and hind wings were not homodynamous organs, it is not probable that the modifications of the two would be so closely correlated. We conclude, therefore, that the elytra are modified wings.

In comparing the tracheation of the elytra with that of the hind wings, the most striking difference observed is the greater

FIG. 52. — Hind wing of a pupa of a beetle.

reduction of the anal area of the former. This is doubtless due to the fact that the meeting of the elytra when at rest in a straight line along the middle of the back does not admit of an expanded anal area.

The extent of the correspondence between the venation and the tracheation of the hind wing of a full-grown pupa is shown by Fig. 52. The principal tracheæ are within the veins, but the branches of these tracheæ extend irregularly through the wing. In the region where the wing is to be folded the secondary vein-like thickenings are only partially supplied with tracheæ.

Although the veins of elytra of adult beetles appear in many cases as well-marked ridges, when elytra of pupæ are prepared, as we prepare wings for this purpose, and examined by transmitted light, we do not find any difference in color between the forming veins and the spaces between them.

With this we conclude our discussion of the venation of the series of forms illustrating the specialization of wings by reduction. The sequence in which the forms have been discussed has been determined merely by convenience, except that we believe that the Plecoptera, which were treated first, resemble the primitive winged insect in the tracheation of their wings more closely than do the members of any other order as a whole. In the next chapter we will give some illustrations of the specialization of wings by addition.

ENTOMOLOGICAL LABORATORY,
CORNELL UNIVERSITY, May, 1898.

ON THE ALTERNATION OF SEX IN A BROOD OF YOUNG SPARROW HAWKS.

DR. R. W. SHUFELDT, C.M.Z.S.

In the early part of May (1898) a collector sent me a brood of five nestling sparrow hawks (*Falco sparverius*), taken from their nest in the neighborhood of Washington, D. C. At the time of reception they were in excellent health and vigor, and all readily fed from the hand bits of raw beef that were offered to them. The quantity of such food each one could eat at a single meal, and the rapidity with which it was digested, were both remarkable facts. A pound and a half of beef was equally divided among them within a quarter of an hour, and was disposed of without any apparent inconvenience to them. Having kept them five or six days in a small basket in which an improvised nest had been made, it was noted with surprise that this temporary habitation remained unsoiled by their excrement, which, however, was by no means the case with the floor for nearly a yard from the edge of the basket, and upon the walls of the corner of the room where the basket was kept, up for nearly an equal distance. In this particular, nestling raptorial birds are at marked variance with such groups as the Passeres and the Woodpeckers, for example, where the parents habitually carry away the excrement of their young, and drop it at a distance from the nest. On or about the sixth day I made a series of photographs of these young hawks, taking them singly, and in one instance two of them together, after which my son chloroformed the five and made a very excellent series of skins of them. Upon dissection and a study of this series a number of interesting points were brought to light. It was noted in the first place that the largest bird of the brood, and of course the oldest one, was nearly double the size of the youngest or last one of the series, while the three others graduated down, from the largest to the

smallest, in almost exact proportions. It was evident, then, that the female had laid the eggs at regular intervals, and very likely three or four days apart, and that incubation commenced immediately after the first egg was deposited. What is more worthy of note, however, is the fact that the sexes of these nestlings

Nestling sparrow hawks. One-half natural size.

alternated, the oldest bird being a male, the next a female, followed by another male, and so on; the last or youngest one of all five being a male. This last had a plumage of pure white down, with the pinfeathers of the primaries and secondaries of the wings, as well as the rectrices of the tail, just beginning to open at their extremities. From this stage gradual development of the plumage is exhibited throughout the series, the entire plumage of the males and the females being very different and

distinctive. It would be interesting to ascertain if this is always the case among the *Falconidæ*, or was only accidental in the present instance. Prof. Alfred Newton, in his *Dictionary of Birds*, page 634, says that owls often begin brooding as soon as the first egg is laid; "but, if my observation is not mistaken, the habit is not constant, even with the same individual bird"; and he adds, by way of explanation, that this "practice unquestionably has its advantages, since the offspring, being of different ages, thereby become less of a burden on the parents which have to minister to their wants, while the fostering warmth of the earlier chicks can hardly fail to aid the development of those which are unhatched, during the absence of father and mother in search of food; but most birds, and, it need scarcely be said, all those the young of which run from their birth, await the completion of the clutch before sitting is begun."

Bendire, in his account of this falcon in his *Life Histories of North American Birds*, says positively that the eggs "are deposited at intervals of a day," but he has nothing to say about the alternation of the sexes in the brood. It is a well-known fact that the eggs of the sparrow hawk vary greatly in form as well as in their ground color and markings. As to this last, it may largely depend, as I have pointed out in my *Comparative Oölogy of North American Birds*, "upon the physical condition of the parent bird at the time of depositing the egg." [1]

If it be true that the sexes alternate in broods of young sparrow hawks, as a regular thing, the present writer has no explanation for the fact, nor has he ever heard of one as having been advanced by any other observer, and it is more than probable that it will be a long time before science will be in possession of the correct interpretation.

In the reproduction of my photograph illustrating this paper, both the birds in the picture are *females*, they being the oldest and the youngest of that sex of the five; in other words, they represent birds numbers two and four of the brood. In order to photograph them I was obliged to build up the little platform of twigs, seen in the figure, for them to rest upon, as

[1] *Report of U.S. National Museum*, p. 476, 1892. This memoir is now entirely out of print.

neither of them could steady itself by holding on to a small branch, — at least, the younger one could not, and its sister could do so only for a short time, — while the oldest bird of this brood could perch well. Sparrow hawks usually build their nests in the hollows of old trees, but occasionally they utilize the abandoned nests of other species.

"NOXIOUS" OR "BENEFICIAL"? FALSE PREMISES IN ECONOMIC ZOÖLOGY.

SAMUEL N. RHOADS.

So many thousands of American dollars have been spent in the last ten years upon the investigations of the United States Department of Agriculture into the economic relations of plants and animals to man, and so much of inestimable value has been accomplished in this direction, that any criticism of the work turned out may seem captious, so greatly does the good outweigh the bad in the gross account. Nevertheless, there is always a disaffected portion of the agricultural classes who sneer at the study of "bugs and bird stomachs" as a most unhappy and worthless waste of taxes. It is too true that the horse sense and field experience of some of these country folk often has a deeper and more practical wisdom in it than the professional zoölogist or botanist can gain in his laboratory work. Even the specialist in some of these studies would fain join in with the cry of the farmer that all our efforts to regulate the ravages of noxious animals and plants are as likely to increase or transform the evil as to correct it. Under former conditions of ignorance there was abundant cause to advocate such a happy-go-lucky theory, but now, thanks be to the persevering efforts of true science and wise legislation, we must all agree that it is our duty to spend and be spent in these researches.

It has been the writer's privilege to belong to both classes in this friendly controversy, and, with a fellow-feeling and sincere respect for each of these, he believes that the following remarks will be taken as evidence of his desire to reconcile and not antagonize the truth-seeking patrons and disciples of husbandry, whether in the field or the laboratory.

It will best subserve the object of this essay to use *Bulletin No. 3* of the United States Department of Agriculture on the "Hawks and Owls of the United States in their Relation to

Agriculture" as representing in one volume the standards by which the economic value of most of the mammals, birds, insects, and reptiles coming under the special notice of the Department have been estimated. It may be added that all subsequent publications of the Department indicate that there has been little change in these standards since the issue of the above-mentioned work of Dr. A. K. Fisher. Published in 1893, this well-prepared and finely illustrated little book represents the highest attainment in the development of economic ornithology yet reached in this country or abroad. Dr. C. Hart Merriam, under whose supervision the work was carried on, in his letter of transmittal to the Secretary of Agriculture, states that only two of the seventy-three species and races of rapacious birds found in the United States "need be taken into account as enemies to agriculture."

Before the investigations which resulted in this verdict were begun, it was the general belief, even among many observing and fair-minded people, that only two or three of the whole number were of any possible use to man. A study of the tabulated lists of stomach contents shows that this reversal of opinion rests solely on two factors. One of these is the relative amount of certain food-stuffs taken by the different species ; the other is the character of the animal food preyed upon, whether formed of species noxious or beneficial to man from the agricultural standpoint.

Granting that the determinations of the first class were accurately made (and there is no reason whatever to doubt them), we may well inquire, By what standard do the zoölogists of the Department of Agriculture decide that certain species of mammals, birds, or insects, are considered to be noxious or otherwise? Nowhere in this work are the two classes defined, nor are any reasons given for the evident distinctions drawn between noxious and beneficial species enumerated in the food lists. The novice in such matters naturally seeks to know on what basis the doctors have decided for or against a hawk or an owl, but he is not informed, except as he can glean an item here and there among the biographies of the various species. This study reveals the following standards : (1) car-

nivorous mammals, mice, rats, gophers, and ground squirrels, as a class, are noxious; (2) birds, in their widest acceptation, which form the food of our hawks and owls are largely of species beneficial to agriculture; (3) reptiles and batrachians forming the prey of rapacious birds in the United States are, as a class, probably as noxious as otherwise; (4) insects preyed upon by these birds belong largely to noxious species; (5) of all the species of animals which are devoured by our rapacious birds in the eastern United States none is so largely and universally devoured or so harmful to agriculture as the common meadow mouse (*Microtus pennsylvanicus*).

I have striven to make these formulæ a conservative summary of the doctor's standards of good and bad as adopted in this valuable work. If it is a just summary, the author believes that the 1893 basis of judgment of our zoölogists in Washington is destined to undergo a radical change in some respects. It may already be doing so. Certain it is that the ideas conveyed in propositions *a*, *c*, and *e* are more or less erroneous, and in some features show a trace of the traditional prejudice which even scientific men often find it difficult to banish from their investigations.

To avoid misunderstanding, let us take the most flagrant case of a so-called noxious mammal, one which forms the bulk of the food of several of our hawks and owls which are nowadays rightly classed as the farmer's friends. The common vole, or meadow mouse (*Microtus pennsylvanicus*), belonging to the same subfamily of rodents as the northern lemming, is rated by nearly all who know him as the incarnation of agricultural pests. On this standard, and this alone, have Drs. Warren, Fisher, and Merriam based their verdict of the economic value of nearly two-thirds of the eastern species of hawks and owls which appear on their rolls of honor. The rough-leg hawk is accorded first place on this list because he eats almost nothing else but meadow mice of this species. But it is a stubborn fact that the case of the meadow mouse has never been proved against him. Not a tithe of the study devoted to his devourers has been given to him, and no scientific analysis of his stomach contents or food habits has yet been put on

record. His plea of not guilty stands good so far as the records of economic zoölogy are concerned. This may sound preposterous to every reader of the statement, but it is undeniable, and not more difficult to believe, after we have inquired into the facts of the case, than the conclusions of the modern zoölogist regarding some of our hawks and owls. "Of course, meadow mice live almost wholly on vegetable food, the grasses and grains of the farm, and that settles it." So retort the great majority, and until a very recent period the writer had thoughtlessly been one of that number. As a farmer, I have had ten years' acquaintance with the habits of the meadow mouse in Pennsylvania and New Jersey, and as a zoölogist, have made about six years' study of the same animal in ten eastern states. In that time about a thousand specimens have been secured and examined, and four hundred preserved for study. Without going into details, the following is a summary of my conclusions as to the economic status of this species, the common meadow mouse, *Microtus pennsylvanicus* of Ord :

1. From 90 to 100 per cent. of the food of this mouse throughout the year is vegetable, of which 60 to 80 per cent. consists of endogenous plants, chiefly grasses; 15 to 30 per cent. consists of exogenous plants, chiefly weeds; 5 to 10 per cent. consists of tubers and roots; and 1 to 5 per cent. consists of grain and seeds.

2. From 1 to 5 per cent. of its diet consists of animal matter such as other meadow mice, and the remains of dead animals.

3. Its vegetable food the year round is largely made up of "grasses," popularly so called, and during the summer season several species of native and introduced weeds form a considerable share of its diet.

4. Its destruction of grasses at all seasons is confined largely, and in the majority of cases almost exclusively, to the rushes (*Juncus*), sedges (*Carex*), salt grass (*Spartina*), Indian grass (*Andropogon*), and other coarse forms which have little or no agricultural value and are rejected by stock either as hay or pasturage.

5. 70 to 80 per cent. of the whole number of meadow mice in any given area restrict their habitat to low, moist soils,

bogs, and clearings, which are classed by the farmer as waste land or untillable meadow, and in these situations they consume almost nothing which would be utilized by the husbandman.

6. 20 to 30 per cent. are found on upland soils. Of these, nearly all confine their foraging to neglected fence rows, abandoned fields, weed patches, brush piles, rubbish, and litter, caused by that clog to American civilization, the shiftless farmer. In these situations the meadow mouse destroys nothing, but utilizes a great deal which otherwise would cumber the ground.

7. The arable land of every well-kept and cultivated farm or nursery, whether in pasture, grass, grain, orchard, truck, or young trees, is practically deserted by this mouse. In short, it can only exist where a food supply is found in conjunction with proper shelter, a shelter in almost every instance synonymous with neglect and waste on the part of the farmer and of utility on the part of the mouse.

8. The meadow mouse rarely eats grain except when the rigors of exceptional winters deprive it of green food. It then confines its appetite to what is found on or in the ground, and which has been exposed by the farmer's improvidence. It very rarely disturbs seeds, fruits, tubers, roots, or vegetables during the growing season and does little damage in winter to those buried in the ground, most of the ravages in these cases being the work of the short-tailed meadow mouse (*Microtus pinetorum*) and the white-footed mouse (*Peromyscus leucopus*).

9. On upland soils the meadow mouse is a surface feeder, forming its runways almost entirely above ground in the shelter of surrounding vegetation and débris. The burrowing of this species is confined chiefly to easily worked, moist lowlands, where it conduces largely to better drainage and an increase of vegetable growth.

To summarize the case briefly, it may be truly said that as a converter of waste vegetable matter into flesh-food for bird and beast the common meadow mouse has no rival in the regions it inhabits. Besides the numerous species of hawks and owls depending almost entirely on this mouse, other carnivorous birds, as the crow, jay, shrike, and heron, devour a

great many. It forms a large part of the menu of several of our mammals, as the wild cat, house cat, fox, marten, weasel, mink, raccoon, skunk, and opossum. The larger species of snakes, the bullfrog, and some of the turtles also devour them. Strike the meadow mouse from the food list of the tens of thousands of animals which devour him in the eastern United States, and the problems of the economic zoölogist would multiply an hundred fold.

The worst charges proved against him are : (*a*) the undermining and tunneling of artificial water barriers ; (*b*) the destruction of a small amount of grain and vegetables not seasonably harvested or housed ; (*c*) the consumption of a very small percentage of grasses which would have been utilized by the farmer ; (*d*) the gnawing of the bark of fruit trees in severe winter weather.[1] The insignificance of these items compared with the value of the mouse as a tiller of the soil, a destroyer of weeds, utilizer of otherwise useless grasses, and a food supply for two-thirds of our carnivorous birds, mammals, and reptiles, is apparent. Exterminate the mouse, and the changed food relations resulting therefrom would cause the extermination of many most beneficial animals and the conversion of others into pests, to the greatest detriment of agriculture. Let us not forget, on the other hand, that any marked decrease of the animals which prey on the meadow mouse is equally to be deprecated, attended as it might be with similar consequences to the "vole plagues" of the old world. To maintain the balance of power between these neutralizing agencies, in the changed conditions imposed by advancing civilization, is the real province of economic natural science.

In 1894, the year following his publication of the volume on "Hawks and Owls," Dr. A. K. Fisher contributed an essay on "Hawks and Owls from the Standpoint of the Farmer," to the *Yearbook of the United States Department of Agriculture.*

[1] Dr. A. K. Fisher, in a recent answer to my inquiries regarding the possible economic value of the meadow mouse, denies that it is anything but a pest, and states that its destruction of trees in nurseries is alone sufficient to condemn it. I have since corresponded with two prominent Pennsylvania nurserymen, Mr. Thomas Meehan and the Wm. H. Moon Co., both of whom deny that they have suffered by this mouse to any extent.

On page 219 I find his first specific arraignment of the meadow mouse, a bit of information wholly lacking in the work of which the doctor's later article was a summary. After mentioning that America is free of the devastating hordes of lemmings which sometimes overrun northern Europe, Dr. Fisher says: "The vole or meadow mouse is common in many parts of this country, and is, east of the Mississippi River, without doubt the most destructive mammal to agriculture. It destroys meadows by tunneling under them, and eating the roots of grass. . . . This mouse also destroys grain and various kinds of vegetables, especially tubers, but probably does even more damage by girdling young fruit trees." There can be no doubt that Dr. Fisher refers primarily to the same species that I have been defending. The injustice of these accusations, as stated, is the more to be deplored, coming as they do from a scientist whose authority is taken as final by a large class of people. This fact, however, should never be construed as a point against the value of hawks and owls and other animals in preventing a vole plague in America. It only indicates that economic zoölogy is in its infancy, and shows the danger of allowing a greater truth to distort the lesser. Four years have elapsed since Dr. Fisher made his statement, — ample time for the officers of his bureau to have discovered that the greater part of the real damage done to vegetation by cutting of grass roots, eating of vegetables, seeds, and grain, and the girdling of young trees, is the work of another member of the vole family, the mole-like, short-tailed, rusty-backed pine mouse (*Microtus pinetorum*). The name mole mouse would better fit this energetic little burrower on whose shoulders rests the onus of most of the sins which we have unwittingly charged to the meadow mouse and the mole.

An hereditary prejudice may become an instinct stronger than our desire for scientific truth. One of the most popular and tenacious fallacies is the human hatred of reptiles and the desire for their wholesale extermination as noxious animals. The same remark will apply in large measure to skunks, minks, and weasels. Without being precise, it may be safely asserted that one-half of the food of our east American snakes consists of

mice (chiefly meadow mice) and insects. The remainder of their diet is made up largely of other snakes and reptiles, birds, batrachia, and fish. Undoubtedly Dr. Fisher recognizes the economic importance of ,the majority of our reptilia and batrachia, yet one cannot escape the suspicion that he has practically classed these as noxious because he has not taken the pains to declare them beneficial. He includes the swallow-tailed kite in the small list of those hawks "wholly beneficial" to the farmer. The tabulated lists and reports show that the food of this species is largely made up of insects, also of snakes, lizards, and other reptiles whose diet is quite as beneficial to agriculture, perhaps, as that of the kite. Nevertheless, the doctor says: "The snakes, lizards, and frogs it destroys, though by no means injurious to agriculture, probably will be regretted by few." We cannot but deprecate such a statement from such a source, for, though it does not condemn these animals, it implies that they are inferior or insignificant in the economic scale, — an imputation utterly without warrant, and serving to perpetuate the popular idea of their worthlessness.

The case of the swallowtail may serve as a striking illustration of nature's mysterious balance of good and evil:

> That not a worm is cloven in vain,
> That not a moth with vain desire
> Is shrivelled in a fruitless fire,
> Or but subserves another's gain.

On the basis of Dr. Fisher's statistics we will suppose a swallow-tailed kite to eat 100 insects, 2 chameleons (*Anolis*), 1 lizard (*Sceloporus*), and 3 grass snakes (*Cyclopis*) in one day. At first thought this should gladden our hearts. But an entomologist will say that 50 of those insects are tiger beetles, dragon flies, and wasps, the two former destroying hundreds of other insects, while the latter captures numerous flies and spiders daily. Avoiding the query as to what kind of insects the other insects eat, the herpetologist declares that the chameleons and the lizard and the green snakes daily devour among themselves about a thousand insects great and small. On the insect basis alone the problems of good and bad in this case are infinitely multiplied. From that point of view it looks, at best, like a

bad case for the kite. From another standpoint the evidence bears hard on the snake. As a variation to insect diet perhaps it has swallowed another snake. Is this an argument in its favor? Or it swallows a toad or frog, both of which live almost wholly on insect life. All this reminds us of Dean Swift's rhyme:

> So, naturalists observe, a flea
> Has smaller fleas that on him prey;
> And these have smaller still to bite 'em;
> And so proceed, *ad infinitum.*

So the plot thickens until we are tempted to despair of the utility of these investigations. A weed is a useful plant misplaced; so also is the hawk, the mouse, the snake, or the insect a noxious animal when we unwisely alter the conditions of its struggle for existence. In nature's order all have their place in the economy of creation.

Two notable groups of injurious mammals in this country are the jack rabbits and the spermophiles, or ground squirrels, of the West. Their combined ravages amount to agricultural losses of tens of thousands of dollars annually and cover a vast extent of country. This condition of affairs has become a national question in the last decade, and was a state question long before that. The vast increase of these rodents is directly due to man's destruction of rapacious mammals, birds, and reptiles, especially of the coyote, or prairie wolf, in these regions; also to the increased amount and improved quality of food supply attending the settlement of the country. This is a matter in which no restoration of primitive conditions is either feasible or desirable, except so far as rapacious animals, wrongly considered harmful, can be encouraged to increase. The effectual devices recommended in the Bulletins of the Department of Agriculture,[1] and adopted by our western brethren for the destruction of jack rabbits and spermophiles, as well as the noxious pocket rat, or gopher, are strong proof of the practical value of economic study along these lines.

[1] *Bulletin No. 4,* "The Prairie Ground Squirrels of the Mississippi Valley," 1893. *Bulletin No. 5,* "The Pocket Gophers of the United States," 1895. *Bulletin No. 8,* "The Jack Rabbits of the United States," 1896.

The following propositions may be considered as a synopsis of the conclusions arrived at in the preparation of this paper :

Firstly, the province of economic zoölogy should embrace (*a*) the study of the functions and habits of living creatures in their relations to nature and to each other, with special reference to the uses and welfare of mankind ; (*b*) the publication of the results of this study in a form most easily accessible to and understood by the public, with a view to correct popular errors and enlist the sympathy and coöperation of the people in the necessary reforms ; (*c*) the perfecting of legislation for the control of injurious, and the protection and encouragement of beneficial, species ; (*d*) the prevention of an unequal administration of economic laws, having in view the peculiar needs and industries of the region involved, and the varying circumstances of environment, the aim always being to secure the greatest good for the greatest number ; (*e*) giving the benefit of doubt as to the economic value of a species to the species in question ; (*f*) the recognition of the fact that true economy cannot ignore the æsthetic and the altruistic in its enforcement of utilitarian laws.

Secondly, concerning the subject of economic zoölogy as specially affecting the United States it may be said : (*a*) that, in general, experience has shown that the *extermination* of any native species on economic grounds is undesirable, but its *restriction*, temporary or continuous, may be a subject for wise legislation ; (*b*) that the damage done by many so-called noxious species is offset in a degree beyond calculation by the fact that they form a large share of the food of beneficial or harmless species, which, if deprived of this source of supply, would be exterminated or become harmful by recourse to an unnatural diet ; (*c*) that in the United States we have large areas so nearly in their virgin state that the balance of nature there existing may be taken as a criterion by which to restore the most natural order compatible with the changed conditions of populated districts ; (*d*) that the unwise destruction of so-called noxious species in this country has not gone so far toward extermination that present-day reforms will fail to be a remedy, as is the case in Europe ; (*e*) that the unity of our

country in the direction of interstate and national legislation has developed early enough for us to conserve the natural productions of the United States in a manner now impossible among older nations ; (*f*) that the unparalleled deforestation and agricultural settlement of the lands of the United States and the importation of foreign species of animals and plants to her shores has so suddenly and materially affected our climatic and zoölogical conditions that nowhere else in the world has there been presented such a variety of important economic problems ; (*g*) that owing to our exceptional facilities for the study of these problems by a corps of trained students and scientists so competent to solve them, and a people so alive to the necessity of education and reform, the civilized world is looking to us for results in economic research commensurate with the money, time, and brains invested, and the demands of a progressive century.

A POCKET MOUSE IN CONFINEMENT.

J. A. ALLEN.

THE arid plains and deserts of the West are inhabited by many kinds of small rodents, some of which, like the pocket mice, the kangaroo rats, and most of the pocket gophers and prairie dogs, are peculiar to these arid areas, and constitute their most characteristic forms of mammalian life. They range in greater or less abundance and diversity of forms from near the northern boundary of the United States to southern Mexico. Their habits of life are such that they must pass much of each year without access to water, and the question has often been raised as to whether they are able to exist without water, deriving sufficient moisture from the seeds and fresh vegetation that form their food, or whether they sink burrows or "wells" to a sufficient depth to obtain it from subterranean sources. In the case of prairie dogs this latter theory has received wide acceptance, but, of course, has never been demonstrated.

The few observations that have been made on captive animals belonging to these several groups have sufficed to show that access to water is not essential to their welfare in captivity; but perhaps no instance affording quite such satisfactory evidence has been given as the case here related. In the summer of 1895 a valued correspondent and well-known naturalist, Mr. H. P. Attwater, of San Antonio, Texas, captured near San Antonio a number of living examples of two species of pocket mice (*Perognathus mearnsi* Allen and *Perognathus paradoxus spilotus* Merriam), which he kept alive during the following winter and kindly sent, still alive, by express to the American Museum of Natural History, New York City, in June, 1896. There were four individuals, two of each of the species named above. One of the larger (*Perognathus paradoxus spilotus*) died on reaching New York, from the effects of the journey; the other lived contentedly for several weeks in an open box

covered with wire netting, but finally escaped and was lost. Of the two smaller (*Perognathus mearnsi*), one soon died, and the other is still living, in apparently good health, after confinement for nearly four years. Mr. Attwater stated that during the time he had them they "fed readily on cane seed, oats, and corn, but had received no water." Also that these little creatures "when kept in confinement become very tame, and seem to like to be handled."

On arriving in New York, water was supplied them regularly for several weeks, but as they appeared to make no use of it, it was soon omitted from the bill of fare, which consisted exclusively of mixed bird seed. Our present captive has had no water offered him for nearly three years. His domicile is a tin box, about 14 inches by 20, and 10 inches deep, open at the top, but with a thick layer of earth at the bottom, which it forms his chief occupation to tunnel and transform, by heaping it up first in one corner and then in another. As he is strictly nocturnal in habits, little is seen of him, unless he is forced to come out by being disturbed in the daytime. He is readily susceptible to the influence of low temperature, and in winter, when the temperature falls to 60° F. or a little below, will remain for days in apparently a state of temporary hibernation.

When an ounce or two of mixed seed is supplied him at one time, he either works industriously till all is hidden away in his underground galleries, or he diverts himself by sorting out the different kinds of seed and making separate deposits of each kind in different corners of the box, above ground.

As no water and no fresh vegetation have been given him for nearly three years, it is evident that the only moisture required for his sustenance is derived wholly from dry bird seed. This seems to demonstrate that these little desert animals, often found living far from any sure source of water supply, are fitted by their organization to exist entirely without access to that element which to ordinary animals is so indispensable, and generally thought to be essential to at least all mammalian life.

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EDITORIAL.

The Need of an American "Leuniss." — Of making books, we are told, there is no end; but there is one kind of book which we Americans need which has yet to be made. The greatest desideratum is a work after the pattern of the German "Leuniss," which is in constant use in every laboratory and museum abroad, but which is unrepresented by any corresponding work in the English language. It is now many years since Leuniss issued the first edition of a synopsis of the three kingdoms of nature, and the work now consists of seven large volumes, two treating of zoölogy, three of botany, and two of mineralogy and geology. These give general accounts of the various groups and follow by giving analytical keys to the principal families, genera, and species, the typical forms being illustrated by thoroughly characteristic engravings. As we have said, there is nothing to correspond in the English language, and for American students a translation would be of little value, as our flora, fauna, and geology are so different from those of central Europe. What we must have is a similar work in which American forms are made prominent. It is true that we have several manuals which include parts of our forms: Jordan has treated of our vertebrates, Gray some of our flowering plants; there is a considerable literature upon insects, ferns, mosses, etc., but the general work has yet to be written. No one man can do the work; it must be by the coöperation of several or even many specialists, and we have in our country the necessary specialists to produce a work which will be far ahead of its German prototype. In the hands of our publishers, our magazines, and of the United States government, are numbers of cuts which could be available for illustration. We wish that we were able to announce that such a work was in preparation, but unfortunately no intimations of the prospects of such a work have reached us. The *American Naturalist* will do all in its power to further such a work, should it be undertaken.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Fouilles a Brassempouy, en 1896.[1] — Several notices have appeared during the last three or four years of the discovery of statuettes and other paleolithic remains at Brassempouy in southwestern France. In a recent number of *L'Anthropologie* MM. Piette and Porterie have given a brief description of their explorations in 1896. In the caves were found large quantities of horse, hyena, and other animal bones, etchings of animals, paleolithic implements, and a small but well-executed carving representing the figure of the human female. The statuette is broken and incomplete, and is not quite symmetrical, yet it is a "remarkable object of art," considering the tools with which the ivory was worked. The stone implements and weapons are similar to those of Cro-Magnon and Gorge-d'Enfer, and those who made them probably belonged to the "Dordogne School of Art" of glacial times.

FRANK RUSSELL.

The Ethnology of Funafutti.[2] — During the summer of 1896 Mr. Charles Hedley, of the "Funafutti Coral Reef Boring Expedition," collected a number of ethnological specimens from the Atoll of Funafutti. Brief descriptions of these with accompanying figures are given, together with numerous references to the literature relating to Polynesia. The author says in his introduction: "On glancing over the ground covered by the following paper my predominant impressions are: firstly, the poverty of our knowledge of Polynesian Ethnology, and the superficial way in which it has been studied; and, secondly, the rapidity with which the knowledge of it that might yet be gathered is vanishing." This warning has been given by many writers and in relation to many other lands as well. We believe that for some time to come those who have an opportunity to study these peoples

[1] Études d'Ethnographie prèhistorique; Fouilles à Brassempouy, en 1896. Ed. Piette and J. de la Porterie. *L'Anthropologie*, T. viii, pp. 165–173.

[2] The Atoll of Funafutti, Ellice Group. Charles Hedley, Australian Museum, Sidney, *Memoir III*, Pt. iv, pp. 229–304.

can occupy themselves much more profitably with the examination of physical characters than in the elaboration of theories of origin and of migrations. The scanty somatological data furnished in this paper show that the Funafutti natives are a brachycephalic (index 82.5) race of medium stature (M 1.67). Mr. Hedley's descriptions of their technic arts are clearly and concisely written, and form a valuable contribution to our knowledge of the culture of Oceania.

FRANK RUSSELL.

The Mounds of Louisiana.[1] — In a paper of twenty pages Professor Beyer has described his explorations among the mounds of northeastern Louisiana. Several skeletons were found, but in such a fragile condition that they could not be preserved. An attempt is made to establish the cranial type from four measurements taken upon five more or less fragmentary skulls, and to prove its southern affinities by comparison with a single Carib skull! With equal success we have recently compared the three principal diameters of the brain case of a series of thirty-three Eskimos with the fifty blacks from Torres Straits, described by Flower! The pre-Columbian type is presumably depicted in the two unnumbered plates entitled "Larto skull" and "Larto skull restored." If this skull were properly oriented, say, about forty-five degrees forward, the "type" would be transformed into an ordinary Indian cranium.

A few specimens of pottery were found, one of which is ornamented with an artistic design containing the Maltese cross and the swastika; that it is "entirely too fine in execution to be ascribed to our North American Indians" is an error manifest to any one at all familiar with American ceramics.

FRANK RUSSELL.

ZOÖLOGY.

The Segmentation of the Head. — This perennial problem has been attacked again by Dr. H. V. Neal,[2] who has based his work upon the early stages of the common dogfish of the New England

[1] Beyer, Prof. George E. *Publications of the Louisiana Historical Society.* New Orleans, La., 1898.

[2] The Segmentation of the Nervous System in Squalus Acanthias. *Bulletin Mus. Comp. Zoöl.*, vol. xxxi, No. 7, 1898.

coast. Only a few categorical statements can be made here concerning his conclusions. The work was begun to ascertain in how far the neuromeres of Locy could be used in solving the problem of the number of segments in the vertebrate head. His conclusions on this point are that these structures are not of segmental value; that in no case are they symmetrical on the two sides of the embryo, and no definite relations to the somites could be ascertained. Again, he has been unable to trace these dorsal structures into the hind-brain neuromeres. Neal regards them, and this opinion seems plausible to the reviewer, as results of unequal growth along the margin of the ventral plate. He differs, too, from Locy in his determination of the posterior limits of the expanded cephalic plate, the posterior boundary of which corresponds to the hinder margin of the later auditory invagination.

Next Dr. Neal considers the neuromeres of Orr. In the hind-brain region he accepts these structures as metameric in character, but points out that Orr's criteria apply only to the later stages; in earlier embryos the constrictions separating the neuromeres are not only lateral, but dorsal and ventral as well. These neuromeres are entirely independent of influence from the mesoderm, and as paired ganglionic enlargements of the central nervous system at once suggest comparisons with the ventral cord of annelids. In the region of the spinal cord, on the other hand, the neuromeres differ somewhat in structure and development from those of the hind-brain, and their existence, at least in part, seems to depend upon the adjacent segments of the epimere.

The so-called neuromeres of the fore- and mid-brain regions are not equal to those of the other part of the brain, as they are later in appearance and are cœnogenetic in character. The two primary vesicles, fore-brain and mid-brain, are each of neuromeric value. So, counting all these, Neal recognizes one each for the fore- and mid-brains, and five in the hind-brain back to the "Urvagus," a total of seven in the primitive head. He fails to see marked differences between the pre- and post-auditory regions of the head, and regards the somites as serially homologous.

The relations of the neuromeres to other apparently segmental structures is then taken up with the following results, the table being slightly altered in its arrangement from that of Neal:

Neuromeres.	Somites.	Nerves (dorsal).	Nerves (ventral).	Visceral Clefts.	Visceral Arches.
I	"a"	I (olf.)	lost		[1]
II	1	oph. pr. V.	III	lost	[1]
III	2	V	IV	mouth	1
IV	3	(V)[2]	(VI)[2]	lost	(1)[2]
V	4	VII	(VI)[2]	1	2
VI	5	IX	(VI)[2]	2	3
VII	6	X	VI	3	4
VIII	7	X	1 spinal[3]	4	5
IX	8	1 spinal[4]	1 spinal[3]	5	6
X	9	2 spinal[5]	1 spinal[3]	6	lost[6]
XI		3 spinal[5]		lost[6]	lost[6]

Neal further concludes that there was originally a correspondence between neuromerism, mesomerism, and branchiomerism, and that a visceral arch has been lost in the region of the fourth neuromere. The segments VIII to XI have been added from the trunk region to the occipital region, the number varying in different vertebrates.

Many details are given of the development of the neural anlagen nerves, somites, etc., and comparisons are made with Amphioxus, the results of which are summarized as follows:

"In agreement with van Wijhe, I homologize the mouth of Amphioxus with the left half of the mouth of Craniota. The first pair of permanent visceral clefts in Amphioxus are exactly homologous with the hyomandibular clefts of higher vertebrates. The eight visceral clefts possessed by Amphioxus at its 'critical stage' (Willey) are exactly homologous with the eight morphological clefts found in some Selachii and Cyclostomes."

Closely connected with the subject of this paper by Dr. Neal is a shorter but suggestive article[7] by Mr. Cole, which, however, is based upon the anatomical rather than the embryological side of the problem. The matter is so condensed as to admit of no satisfactory abstract, since it deals not with new investigations, but is rather a summary of conclusions drawn from existing knowledge.

[1] Possibly represented by labial cartilages.

[2] Theoretical relationships.

[3] From the first three roots of the embryonic hypoglossal.

[4] Fuses with dorsal ganglion of X.

[5] Ganglia disappear in development.

[6] Found in Diplospondyli.

[7] Reflections on the Cranial Nerves and Sense Organs of Fishes, by F. J. Cole. *Trans. Liverpool Biol. Soc.*, vol. xii, 1898.

The Stomach of Migrating Salmon. — An interesting study of the histological changes which the digestive tracts of salmon undergo during the migrations of these fishes from salt to fresh water, and the reverse, has been made by G. L. Gullard.[1] At about the time the salmon begin to ascend the rivers, or even before, their digestive tracts are affected by a desquamative catarrh by which most of the digestive epithelium is shed. After the fish have reached the high waters and laid their eggs, the stomach reassumes its normal epithelium, and on their return to the sea the epithelium of the intestine is regenerated. The desquamation is evidently not directly or indirectly dependent on the action of fresh water, for it may occur in fish that are still in salt water. It is more probably associated with changes in the feeding habits of the fish correlated with the breeding season.

G. H. P.

Terminology of the Central Nervous System. — The Association of American Anatomists has issued in the form of a pamphlet the majority and minority reports of its committee on anatomical nomenclature. The reports deal with the terminology of the central nervous system. The majority report, after a historical summary, discusses briefly four categories of terms: first, twenty-three terms common to the list of the committee's secretary and that of the Anatomische Gesellschaft; secondly, seventy-eight terms common to both lists, but with slightly different usages; thirdly, fifteen terms largely different in the two lists, but receiving considerable American support; and, finally, two hundred and fifty-nine terms differing more or less from those adopted by any other organization. The majority report is obviously a radical measure, and it is against this side of it that the minority report is directed. While the reports contain some happy suggestions as to changes in particular terms, and much that is valuable on the principles of a logical and convenient nomenclature, they differ from each other so radically that anything approaching the adoption of a uniform system on the part of the committee would seem well-nigh impossible.

G. H. P.

Processus Odontoideus Atlantis Hominis. — In 126 atlas vertebræ examined by Dr. E. Funke,[2] two were found to have what may be

[1] Gullard, G. L. The Minute Structure of the Digestive Tract of the Salmon, and the Changes which Occur in it in Fresh Water. *Anatomischer Anzeiger*, Bd. xiv, pp. 441–455.

[2] Funke, E. Ueber einen Processus Odontoideus Atlantis Hominis. *Anatomischer Anzeiger*, Bd. xiv, pp. 385–390.

called odontoid processes. These processes have been interpreted in the following way: the bodies of the atlas and axis, like those of most other vertebræ, have each two centers of ossification, a cranial and a caudal one. Ordinarily all these four unite in the adult to form the body and odontoid process of the axis, the atlas having no true body. In the exceptional cases above noted, it is supposed that only the caudal ossification of the atlas united with the body of the axis to form the odontoid process, and that the cranial ossification remained in place, thus producing an odontoid process on the atlas. G. H. P.

Comparative Anatomy for Medical Students. — In the June number of the *Columbia University Bulletin*, Prof. G. S. Huntington has an able article on the importance of vertebrate comparative anatomy for medical students. The article outlines the policy which is shaping the teaching of anatomy in the medical department of Columbia, and will be encouraging to those teachers who, in preparing students for medical studies, have insisted upon the importance of vertebrate comparative anatomy as a key to the interpretation of human structure. G. H. P.

The "claspers" or modified posterior edges of the pelvic fins of Elasmobranchs have been made the subjects of study by H. F. E. Jungersen.[1] The skeleton, muscles, glands, and integumentary investments of these organs are described first in Chimæra and then in the sharks and rays. The probable function of these parts is alluded to, and while no new observations are recorded on this little-known subject, the inference is drawn from the structure of the parts that they cannot be used as "claspers" or external "holders," but they can be effective as hold-fasts only after they have been inserted in some opening such as the female cloaca. G. H. P.

Cope's Lectures on Vertebrates.[2] — For the past half dozen years students of the vertebrates have found the first edition of the present work indispensable, as it brought into a small compass a clear and concise summary of all the labors of Professor Cope upon the classification of the vertebrates, living and extinct. As the previous edition

[1] Jungersen, H. F. E. Ueber die Bauchflossenanhänge (Copulationsorgane) der Selachiermännchen. *Anatomischer Anzeiger*, Bd. xiv, pp. 498–513.

[2] *Syllabus of Lectures on the Vertebrata.* By Edward D. Cope. With an introduction by Henry Fairfield Osborn. University of Pennsylvania, 1898. $1.25 (paper covers $1.00).

was prepared primarily for the use of the students of the University of Pennsylvania, and was not placed on general sale, its use was greatly restricted. The present edition has been brought up to date, and its preparation was one of the last works of the author, the preface bearing the date 1897. Among the changes of interest, we note the inclusion of not only Balanoglossus but Cephalodiscus and Rhabdopleura in the chordates; the recognition of Paleospondylus and the Astracopphri as cyclostomes and the rehabilitation of the Stegocephali. The work will long remain a necessary assistant to every student who wishes to really study vertebrates. One may differ with the author upon minor points of his system, such as the retention of his groups Rhachitomi and Embolomeri; with the exclusively osteological basis of his classification, which, however, was a necessity in dealing with fossil forms, or with the outrageous forms, — carbonic, cumbric, etc., — adopted for the geological periods; but when all this fault is found there remains behind a work of which any one might be proud.

The introduction to the volume consists of a short sketch by Professor Osborn of the life and the works of Professor Cope, presenting in clear form the many advances both in knowledge of fact and in generalization which we owe to America's greatest comparative anatomist.

Packard's Text-book of Entomology.[1] — Professor Packard's new text-book of entomology appears at a most opportune time. The influence of the book because of the kind of entomology it illustrates and illumines will be very great and very valuable. As a reference and text-book of the morphology, physiology, and development of insects, it takes for these lines of study that position of authoritative and indispensable guide which *Comstock's Manual* takes for the study of the taxonomy and "life-history" of insects. With these two manuals of insect study, the English-speaking students of entomology are better provided with book guides than are the students of any other country.

Because there are hundreds of thousands of insect species, and because the finding and setting in order of species was the first business of naturalists, most entomologists have given most of their time to helping in this business of species finding and distributing.

[1] *A Text-book of Entomology, including the Anatomy, Physiology, Embryology, and Metamorphoses of Insects.* By A. S. Packard, M.D., Ph.D. The Macmillan Co., New York, 1898. 8°, pp. xvii, 729, with 654 figs. $4.50.

The work is necessary and will never be abandoned. But while some of us have kept exclusively at this sort of work, others have begun to study insects from other points of view. What these others have done is pretty fairly set out in Dr. Packard's new book. From a knowledge of what has been done come the knowledge of what there is to do and the inspiration to do it. If this work done and to be done is an especially interesting and especially important kind of work, the pioneer text-book of such work is especially valuable and helpful. That the kind of entomology treated of in Dr. Packard's text-book is especially important and interesting will not be questioned in 1898 nor thereafter.

The author of such a text-book has a large undertaking on his hands, and one to which a great deal of time may be given. To decide on the quantity of matter to be included and the character of its treatment is a nice question, and opinions regarding it will most certainly vary. Dr. Packard is an entomologist widely acquainted with the work done by other entomologists and zoölogists, and especially capable, from his own wide range of study, to judge of the value of this work. He is in a position to write as an authoritative critic. We (if there are others of my way of thinking) should wish, then, to have him present in a text-book of entomology what seem to him, from his own investigations and from his knowledge of the observations and theories of others, the facts and theories accepted by the consensus of authority. We want a well-digested, clearly presented, authoritative statement of the present knowledge of insect morphology, physiology, and development. This, it seems to me, Dr. Packard has not wholly done. The author has wished to be very fair. He presents to us the original sources of his knowledge. He displays the contradicting observations and speculations of investigators; he quotes German and French writers in their own words and sometimes in their own language; he is strenuous to give credit to whom credit is due. This is delusive fairness. It is too much to expect, it is confusing, it is impossible for a text-book to give credit for all facts. It is impossible for Dr. Packard to give all the observations and theories pertinent to the structure and physiology of the Malpighian tubules or to the origin and development of the imaginal discs. But it is wholly possible for him to give us, regarding the Malpighian tubules and the imaginal discs, a statement of the present knowledge of these organs made by the man best fitted, probably, of all men in America to make an authoritative statement of such knowledge. This is one conception of what such a text-book from Dr. Packard should

be; and it probably is not Dr. Packard's; or if it is, he has not had the time to attempt such a complete digestion of the mass of observations and theories which he has had before him; and the matter of time is an influencing one in almost all work.

Dr. Packard's text-book need not be compared with similar ones in other languages, because there is no other one which at all approaches it in comprehensiveness or construction. Kolbe's *Einführung in der Kenntniss der Insekten* does not touch embryology nor post-embryonal development, nor hardly physiology; Camerano's *Anatomia degli Insetti* is insignificant; Lowne's *Blowfly* and Miall and Denny's *Cockroach* are of a different type, and one lacks authority while the other is old. Dr. Packard's is the one book covering the field of its subject, and it becomes at once the authoritative text.

It will be unnecessary to call attention to details of the book's construction. The logical arrangement and sequence of subjects, the wealth of illustration, the full lists of well-selected references, and the complete index are noticeably good features. The author is a veteran bookmaker and understands the importance of caring for the convenience of the book-user. The publishers have admirably aided the author in making the book usable, and have put it into substantial and pleasing form. The type-face is large and clean, and the "style" characteristically good.

The book is indispensable to teachers of entomology and zoölogy and to students of insect morphology and development. Whether it will be extensively used in "agricultural and technical schools and colleges," is a matter to be determined by time. There is no doubt that it ought to be so used, and cannot fail, in any case, to help better the opinion entertained by foreign scholars of American biology. Zoölogists and entomologists are under real obligations to Professor Packard for the material aid he has given them in writing the book.

STANFORD UNIVERSITY, CALIFORNIA. VERNON L. KELLOGG.

Faune de France.[1] — This is a convenient handbook for the purpose of the determination of the insects of France. It treats of all of the orders of this class except the Coleoptera, which form the subject of an earlier volume. It consists entirely of analytical tables. These include all of the genera represented in France; and, except in the case of a few families, tables of species are also given. The

[1] Aclogue, A. *Faune de France.* Paris, J. B. Bailliere et Fils, 1897. 12mo, 516 pp., with 1235 figs. $2.00.

work has the appearance of being well done; but its aim is purely systematic, and the point of view is that of a generation ago, when, much more generally than now, the object of the student was to label the specimens in his collection and to arrange them in an orderly manner. C.

Revision of the Melanopli.[1] — This is a monograph of that division of the Acridiidæ or short-horned grasshoppers which includes our common red-legged locust, the Rocky Mountain locust, and other well-known forms. The group includes thirty genera (eighteen new) and 207 species, of which 115 are here described for the first time. As the work is done in that thorough manner which is characteristic of Mr. Scudder's monographic work, it is obvious that this is an exceedingly important contribution to our knowledge of the orthopteran fauna of North America. One cannot go over the pages of the book before us without being impressed with the devotion of the worker, as shown by the infinite care and patience with which the descriptions have been made. C.

Handlirsch's Monograph of the Phymatidæ; Fernald's Pterophoridæ of North America. — Handlirsch's "Monographie der Phymatiden" (*Ann. k. k. nat. Hofmuseums*, 1897, Bd. xii, No. 2, pp. 127–230, taf. 4–9) is a well-planned and well-executed systematic study. The work of previous investigators is stated in sufficient detail, and there are brief notes relating to the morphology, anatomy, development, life-habits, geographic distribution, systematic position, and relationships of the family. The tabular separations of the subfamilies, genera, and species, and the descriptions of the genera and species are clear and concise; three new genera and twenty-eight new species are described. Handlirsch recognizes three subfamilies, the Phymatinæ, Macrocephalinæ, and Carcinocorinæ; of Phymata, the only genus of the Phymatinæ, there are twenty-five species, two from Europe and the others from North and South America and the West Indies. Four species are noted from America, north of Mexico, and of *Phymata erosa*, the well-known ambush-bug, many subspecies, ranging from Canada to Chili, are described. Scott's two species from New Zealand are doubtfully placed here. There are six genera and forty-three species of Macrocephalinæ; thirty of the latter are

[1] Scudder, S. H. Revision of the Orthopteran group Melanopli (Acridiidæ) with special reference to North American forms. *Proc. U. S. Nat. Museum*, vol. xx, pp. 1–421, with Pls. I–XXVI.

placed in Macrocephalus. The species of Macrocephalus have the same distribution as those of Phymata, and, as with Phymata, but four species are found in America, north of Mexico. The habitat of the single species of Oxythyreus is not known; Amblythyreus, six species, Cnizocoris, two species, and Glossopelta, three species, are all from the Indo-Asiatic region; Agrenocoris, with a single new species, is, with doubt, credited to Mexico. The subfamily Carcinocorinæ consists of two genera, Carcinocoris, two species from Indo-Asia, and a single species of Carcinochelis, described as new, from an unknown habitat. The plates and cuts adequately illustrate the text.

A striking contrast to this careful, original monograph of Handlirsch may be found in "The Pterophoridæ of North America," by C. H. Fernald (*35th Ann. Rept. Mass. Agric. College*, January, 1898, pp. 83–163, 9 pls. Separate: January, 1898, 80 pp., 9 pls.).

Professor Fernald devotes less than a page to geographical and geological distribution, economic importance, and natural enemies; the history and structure of the family are stated in less than eight pages, and there are very brief notes on the habits and early stages. The greater part of the work is given over to an account from a systematic standpoint of the six genera and fifty-eight species found in America, north of Mexico; a notice of *Orneodes hexadactyla* is added.

The whole work is essentially compiled; it contains hardly an original line from a biologic point of view; of early stages the descriptions and accounts are, almost without exception, surrounded by quotation marks, and though the author is stated, the reference to the place of publication is frequently omitted. While this paper by Professor Fernald may serve the purpose of calling attention to our plume-moths or feather-wings, it will hardly enhance the reputation of its author. It shows everywhere carelessness in preparation and haste in publication. Important references to descriptive matter, previous notices of food-habits, of early stages, and records of habitats are omitted; species treated in the text are left out of the tables; a species appears in the text under one name and in the table under a different name; the bibliographic references are not uniform; Zeller's paper (1873) is cited, on the first pages, "Beit." and later on as "Verh. z.-b. Ges. Wiens."; the number of specimens studied is given in some cases; in others it is not given; direct detailed references from text to plates are not given.

Plate I shows the external morphology of *Pterophorus monodactylus;* of the other plates two are given over to venation, the others to geni-

talia. The genitalia, though thus elaborately illustrated, are hardly referred to in the descriptions. On page 135 *Pterophorus ambrosiæ* is put down as a synonym of *P. inquinatus*, a conclusion that seems more than doubtful when Pl. IV, Figs. 3, 4, and Pl. VI, Figs. 14, 15, are compared.

The index of genera and of species issued with the separately paged reprints might have been omitted, as the references are to the original pagination, not to the pagination of the reprint. January, 1898, on both the report and reprint, should not be considered as the date of publication, as the first advance copies were not sent out from the state printers until March 31, 1898.

Finally the publication in an agricultural report of a systematic account of a family of so slight economic interest as the Pterophoridæ may well be criticised, especially when so many species of prime importance to agriculturists await adequate treatment.

S. H.

BOTANY.

The Morphology of Spore-producing Members. — With the improvements in microscopical technique and the increasing availability of tropical types there have been during the last decade great additions to our knowledge of the structure of all groups of plants, and the pteridophytes have not been neglected. As might be expected, these investigations have not always confirmed the older views, and perhaps nowhere is this more marked than among the ferns. Until quite recently it has been generally accepted that the Leptosporangiatæ, especially the Hymenophyllaceæ, were the more primitive ferns from which the Eusporangiates, the Ophioglossaceæ, and Marattiaceæ, have sprung. The result of these recent studies has been to throw much doubt upon this view, and to make it reasonably certain that the latter groups are really the older ones, while the leptosporangiate ferns represent comparatively recent specialized types, which have arisen from eusporangiate ancestors.

No more important contributions to this very interesting subject have been made than the series of studies upon spore-producing members, of which the present paper[1] is the third. Professor Bower

[1] Bower, F. O., Sc.D., F.R.S. Studies in the Morphology of Spore-producing Members, Marattiaceæ. *Phil. Trans. Roy. Soc.*, Ser. B, vol. 189, 1897, pp. 35–81, Pls. 7–11.

has already given us a very accurate account of the development of the sporangia in the lycopods, Equisetineæ, and Ophioglossaceæ, together with most important conclusions as to the origin of the different sporangial types and the relations of these to one another. In the present paper he has taken up the second order of the Eusporangiatæ, the Marattiaceæ, and has given us by far the most complete account of the sporangia of these interesting ferns that has ever been published. All of the existing genera are treated at length, and in addition there is a most valuable discussion of the relation of these to the different fossil types.

The Marattiaceæ comprise at present four genera, two of them monotypic, of tropical ferns of very characteristic structure. Of these, Marattia is represented in both the Old and New World, but the others are more restricted in range. Danæa is peculiarly American; Angiopteris and Kaulfussia, each with but a single species, belong to the Old World.

The Marattiaceæ show many primitive structural characters, and it is now known that most of the palæozoic ferns were closely related to existing marattiaceous types. Owing to the difficulties in procuring suitable material for studying the development of the sporangia, the earlier studies on these were mostly fragmentary, and entirely confined to the two genera Marattia and Angiopteris. This makes the careful study here given of the sporangia of Danæa and Kaulfussia of more than common interest.

In all the Marattiaceæ except Angiopteris the individual sporangia are imperfectly delimited, and the sorus is often spoken of as a "synangium," although it is much more probable that this is the primitive condition than a case of cohesion of originally free sporangia. Bower very properly considers each group of sporogenous cells as a single sporangium, and speaks of it as a sporangium.

The development of the sporangium is much alike in all of the genera. The sporogenous cells arise, as a rule, from a single hypodermal cell, whose sister-cell forms part of the wall of the ripe sporangium. Exceptions occur and it is not always possible to refer the sporogenous complex to the division of a single mother-cell.

In Danæa the sori are much elongated, and almost completely cover the lower surface of the sporophyll, extending from the midrib to the margin, and almost or quite touching each other laterally. In this genus the sporophylls have the segments decidedly smaller than the sterile leaves, and in this respect Danæa recalls many leptosporangiate ferns, or the Ophioglossaceæ. The occasional presence of

imperfect septa in the loculi and a partial overarching of the sorus by the leaf tissue recall the structure of the sporangium in Isœtes, which it has been suggested more than once may possibly be remotely related to the Marattiaceæ.

Kaulfussia differs from Danæa principally in the much wider expanse of the leaf surface and a consequent separation of the small, nearly circular sori; but in essential structure the sporangia of the two are much alike, and Bower considers that the two are nearly related.

Marattia and Angiopteris have been studied more or less completely by other investigators, but they were also examined carefully by Professor Bower, and some additional information in regard to the development of both of them was obtained. In Marattia the presence of a mechanical tissue, having to do with the dehiscence of the sporangium, and an occasional partial septation of the loculus, as in Danæa, are the most noteworthy of these new facts. In Angiopteris abnormalities were sometimes noted, the most striking being sporangia of unusual size, suggesting a condition intermediate between the normal sporangia and the synangia of the other genera. Angiopteris alone is provided with a genuine, though rudimentary, annulus, and there are special thin-walled cells upon the ventral surface of the sporangium where it opens.

A comparison of the number of spores produced is made, from which it appears that Angiopteris and Kaulfussia mark the extremes. The former produces approximately 1450, the latter 7850 spores in each sporangium, numbers far in excess of those in any leptosporangiate ferns.

An interesting comparison is made with the lower members of the leptosporangiate series of ferns, and it is pointed out that the type of sporangium found in the Marattiaceæ has certain resemblances to that of the Osmundaceæ, Gleicheniaceæ, and Schizæaceæ, a point which may well be borne in mind in future studies as to the affinities of the lower Filicineæ.

A most valuable summary of the more important facts connected with the fossil Marattiaceæ is given, from which it appears that while certain of the fossil genera, *e.g.*, Danæites, conform closely in structure to existing types, others are to some extent synthetic in character. Thus Scolecopteris combines characters belonging to Marattia, Kaulfussia, and Angiopteris, while others show characters which would seem to indicate that they are forms connecting the Marattiaceæ with the lower leptosporangiates.

In summing up the evidence obtained from a comparative study of the living and fossil Marattiaceæ, Professor Bower recognizes the difficulties in reaching positive conclusions. However, while admitting that any conclusions reached must be subject to modification, his own view (p. 69) is that the circular sorus, like that found in the fossil Asterotheca, probably is the primitive type from which the others have been derived. The difference in form of the sorus, especially the extreme elongation in Danæa, is correlated with extension of the leaf surface. In another direction, by repeated constriction of the elongated sorus, the numerous scattered sori of Kaulfussia may have arisen.

It is to be regretted that our author did not make a fuller comparison of the Marattiaceæ and Ophioglossaceæ. He expresses no opinion as to the affinities of the two, beyond calling attention to the resemblances between the sporangial spike of Ophioglossum and the elongated sorus of Danæa, which resemblance he does not regard in the light of a true homology.

We are promised a study of the Leptosporangiatæ which will be awaited with keen interest by all students interested in these most important problems, which bear directly upon the question of the origin of the flowering plants as well as the ferns.

STANFORD UNIVERSITY,
May, 1898.

DOUGLAS HOUGHTON CAMPBELL.

Recent Inexpensive Popular Literature on Mushrooms. — The following papers more or less useful to collectors and eaters of fleshy fungi have come to our table within the year:

"Suggestions to Collectors of Fleshy Fungi," by Prof. L. M. Underwood. Reprinted from *Bull. 80 Alabama Agri. Exp. Station.* Cambridge Bot. Supply Co., Cambridge, Mass., July, 1897. 14 pp. Price, 25 cents.

"Mushrooms and Their Use," by Charles H. Peck, State Botanist of New York. 8vo, 80 pp., 32 cuts. Reprinted from *Cultivator and Country Gentleman*, Albany, N. Y., 1894. Cambridge Bot. Supply Co., May, 1897. Price, 50 cents.

"How to Grow Mushrooms," by William Falconer. *Farmers' Bulletin No. 53*, Division of Vegetable Physiology and Pathology. U. S. Dept. of Agriculture, Washington, D. C., March, 1897. 8vo, 19 pp., 14 figs. Free on application.

"Observations on Recent Cases of Mushroom Poisoning in the District of Columbia," by F. V. Coville. *Circular No. 13.* U. S.

Dept. of Agriculture, Division of Botany, Dec. 1, 1897. 21 pp., 21 figs. Free on application.

"Collecting and Preparing Fleshy Fungi for the Herbarium," by Prof. Edward A. Burt, *Botanical Gazette*, March, 1898. 8vo, 14 pp., 1 pl. Reprints of this may be had from Cambridge Bot. Supply Co., Cambridge, Mass.

"Some Edible and Poisonous Fungi," by Dr. W. G. Farlow, Professor of Cryptogamic Botany in Harvard University. *Bulletin No. 15*, Division of Vegetable Physiology and Pathology. U. S. Dept. of Agriculture, Washington, D. C., June, 1898. 8vo, 17 pp., 10 lithographic plates, one colored. Free on application. This latter publication, in particular, should be in the hands of every one who desires to distinguish wholesome from noxious species. To this end a large edition has been issued and the paper has also been included in the yearbook of the Department of Agriculture for 1897.

ERWIN F. SMITH.

Merrill on Lower California.[1] — The attention of botanists who are interested in œcology is called to this paper on account of a number of very interesting plates illustrating the strange vegetation of this peninsula. Very odd and striking are the pictures representing three of the common trees of this region, *viz.*, *Cereus pringlei*, *Fouquiera columnaris*, and *Veatchia cedrocensis*, the latter known as elephant wood. They are desert species which have become profoundly modified to adapt themselves to an adverse climate. Each one illustrates the extreme flexibility of living things, and at the same time speaks volumes regarding their hard, age-long struggle for existence, during which to hoard water every transpiring organ has been thrown away or reduced to the smallest possible compass. Concerning the Fouquiera, which reaches a height of 40 feet and a base diameter of 15 to 18 inches, Professor Merrill says: "A landscape of these pole-like forms, with their thorny branches and few small, brittle, thick, yellow-green leaves is weird in the extreme, and particularly so about dusk. Dry, hot, leafless, noiseless, and apparently lifeless, it conveys vividly to the imagination the idea of a burnt-out world."

ERWIN F. SMITH.

[1] *Notes on the Geology and Natural History of the Peninsula of Lower California.* By George P. Merrill, Curator, Dept. of Geology, U. S. National Museum. Washington, Gov. Printing Office, 1897.

Whitney on Florida.[1] — For the same reason as the preceding we wish to call attention to the plates which accompany this report. They illustrate excellently well some of the peculiar features of the plant associations in Florida. Among these may be mentioned views of (1) high pine land at Ft. Meade, (2) high pine land at Altoona, (3) hammock land at Ft. Meade, (4) border line between scrub and high pine land at Altoona, (5) the characteristic vegetation of the Etonia scrub. Concerning the Etonia scrub, which has been a source of speculation and wonder to every botanist who has seen it, we quote the following:

"The great Etonia scrub formation was examined at Altoona. It is an impressive sight to stand at the border line between the scrub and the high pine land and notice the difference in the character of the vegetation. The high pine land is open, the trees are large and vigorous, and the ground is covered with a crop of grass which gives very good grazing for cattle. The vegetation is quick and generous, and the most tender garden plants will grow luxuriantly if properly attended to. These conditions stop abruptly at the edge of the scrub. The boundary between the high pine land and the scrub can be located without trouble within a few feet. . . .

"In the scrub there is a dense growth of scrub oaks and low bushes and plants, all having thick leaves protected to the utmost from loss of water by evaporation, by the property that desert plants have of turning the leaves up edgeways to the sun, to expose as little surface as possible to the direct rays. No grass is found, and only the most hardy desert plants grow. When pines grow it is the dwarf spruce pine and not the long-leaf pine, while on the other hand the spruce pine is not found across the border in the high pine lands proper.

"The full-grown scrub vegetation reaches about the height of a man's head. . . . This scrub growth stretches out at this place in an unbroken line for ten or fifteen miles to the northward, and the whole country presents a most desolate appearance. The country is generally rolling in both the high pine land and scrub. There are lakes at which the scrub and the high pine vegetation meet at the water's edge. There is no indication from the topography of the country of any difference in the climate over the two soils. Very few attempts are known to have been made to cultivate the scrub

[1] A Preliminary Report on the Soils of Florida, by Milton Whitney, Chief of Division of Soils. *Bulletin No. 13*, Division of Soils, U. S. Dept. of Agriculture, Washington, Gov. Printing Office, June, 1898.

lands. A few efforts to grow truck and oranges are known to have been failures. It is generally believed that the scrub is colder at night, and that frosts are liable to occur over these areas when they do not occur over the high pine land. There is no apparent reason for this, however, in the topography of the country."

Professor Whitney finds no chemical or physical difference in the soils which would account for the diverse vegetation, and is driven to the conclusion that "the only explanation for the difference in the character of the vegetation is that it is accidental, and that the one kind of crop or the other received a start and simply spread, the two kinds of vegetation not being capable of growing together." This is an explanation which does not explain, and we are not inclined to accept it as a final word.

ERWIN F. SMITH.

Forests of Wisconsin.[1] — Those who are interested in the forestry problems of this country will desire to read this report from cover to cover. It is written by a competent forester. It deals with the past and present forest conditions of the so-called pineries of Wisconsin, *i.e.*, the northern half of the state. It is based on personal explorations and on data furnished by trustworthy lumbermen. To obtain the materials for this report Mr. Roth visited every county in the district, making a careful study of its forest cover. When one considers the infinitude of details involved in such a survey, the wonder is that the author has been able to represent things so clearly. No one can read this report without feeling that the work has been well done, or without wishing that Michigan and other pine-woods states might set on foot similar surveys. Unless something of this kind is done, either by the states or by the general government, we shall never know where we are in the matter of timber supply, or fully realize the necessity of forest care and conservation, until we are brought face to face with a scarcity of timber and all its resultant evils.

This survey shows that of the original 17,000,000 acres of forest in northern Wisconsin, 8,000,000 have been cut over by lumbermen; that 40% of this vast area is practically a desert; and that the remaining 60% is now producing nothing better than firewood. Much of this land is worthless for farming purposes and should be

[1] Forestry Conditions and Interests of Wisconsin. By Filibert Roth, Special Agent, with a discussion by B. E. Fernow, Chief of Division of Forestry. *Bulletin No. 16*, U. S. Dept. of Agriculture, Division of Forestry. Washington, Gov. Printing Office, 1898. 73 pp., 1 map.

reforested. The greater part of it is now owned by lumber firms that have removed all the merchantable lumber and would now be glad to sell it to the state for a merely nominal sum. By properly planting this land and policing it (to prevent forest fires), often merely by keeping out the fires, the state authorities might readily reforest the larger part of it, and thus add greatly to the wealth of the state. The *Bulletin* deals with such topics as topography, soils, climate, drainage, ownership, forest fires, changes on cut-over lands, the outlook, etc. Each of the more important timber trees is considered by itself and there are occasional notes on other vegetation. Since the pine lumber has been cut the country is drying out. This is shown in many ways, *e.g.*, by the disuse of corduroy roads, by the cultivation of former swamps, by the lessened flow in rivers, and finally by the fact that the hemlock spruce, which covers all the eastern, middle, and northeastern part of this great tract, is dying out. Of this species no young forests are coming on, and many of the old trees are dead at the top. This decadence is attributed to the fact that the hemlock has a superficial root-system, and is therefore sensitive to changes in the moisture content of the surface soil. That portion of the report devoted to forest fires and to the very detrimental changes they bring about on cut-over lands is particularly interesting. By neglect to reforest these lands it is estimated that the state of Wisconsin loses annually 800,000,000 feet board measure of merchantable lumber.

ERWIN F. SMITH.

Porter's Translation of the "Bonn" Text-book of Botany. — The first German edition of the *Lehrbuch der Botanik für Hochschulen*, prepared by Prof. Eduard Strasburger and his colleagues Schimper, Noll, and Schenk of the University of Bonn, appeared in 1894. The result of a felicitous coöperation upon the part of four able specialists working in the same laboratories and under the guidance of a master mind, this book immediately took high rank among works upon its subject. It has deservedly received much favorable comment and little adverse criticism. It has passed into its second German edition, and is now so generally known on this side of the Atlantic, as well as in Europe, that it is needless here to comment upon its qualities. The English edition,[1] lately prepared by Dr. H. C. Porter, Assistant Instructor of Botany at the University of Pennsyl-

[1] *A Text-book of Botany.* By Strasburger, Noll, Schenk, and Schimper. Translated from the German by H. C. Porter. Published by the Macmillan Co., London and New York, 1898. Price, $4.50.

vania, shows abundant evidence of care and discrimination in its execution. The task of translation has evidently involved no small difficulty. There is no doubt that the German technical vocabulary in botany, partly from the greater plasticity and power of combination in the language itself, partly from the patience and discrimination of the German investigators, has developed a considerable number of apt and valuable descriptive terms which are without exact or generally recognized equivalents in the English. The precise German terminology for the varied structures which in English are loosely termed "bracts" furnishes a case in point. In most instances Dr. Porter's selection of terms seems excellent. Occasional renderings, such as *haulm* instead of the more general *culm*, for the German *Halm*, appear less fortunate. The phrasing of the translation is good, being exceptionally free from labored constructions and foreign idioms. One unfortunate change from the original German edition is the failure to indicate the limits of the individual authorship. This cannot, we believe, be too clearly shown in all joint productions. Professional botanists who are acquainted with the tastes and special pursuits of the Bonn staff, may not need to be told that anatomy or inner morphology was treated by Strasburger, physiology by Noll, general morphology of the cryptogams by Schenk, and of the phanerogams by Schimper, but the ordinary student using an English edition of the text-book will scarcely grasp by intuition the interesting details of this coöperative plan. The print and general make-up of the translated edition are eminently satisfactory, although the small colored illustrations — presumably introduced at first for commercial rather than scientific or esthetic reasons — are not so carefully executed as in the original German edition.

B. L. R.

Catalogo de Plantas Mexicanas (Fanerógamas).[1] — Dr. Urbina, the botanical director of the Mexican National Museum, has recently issued a large octavo of nearly 500 pages, enumerating about 3000 species of Mexican phanerogams. Authorities are duly cited and to some extent bibliography is given. Such *exsiccati* are enumerated as are represented in the herbarium of the Museo Nacional, comprising chiefly the collections of Peñafiel in Hidalgo, Schaffner in San Luis Potosi, Bárcena in Jalisco, Urbina in the Valley of Mexico, and Pringle in various states of the republic. Numbers, localities, and dates of collection are also entered. The catalogue reflects credit

[1] Collated by Dr. Manuel Urbina, and published by the Museo Nacional, City of Mexico.

upon the energy and industry of Dr. Urbina, and is unquestionably the best production of its kind which has issued from Mexico. It will doubtless stimulate local interest among Mexican botanists, but for several reasons can assist but little the foreign students of the Mexican flora. It is far from being a complete enumeration of the known species of the country, and its extent is determined neither by geographic boundaries nor by the limits of natural orders, but rather by chance, since, as it appears, only such species are mentioned as happen already to be represented in the Museo Nacional. A valuable feature of the catalogue is the introduction of a considerable number of local vernacular plant names which, now that they are coupled with their Latin equivalents, may well give clues to the real identity of various Mexican drugs and officinal plants which reach our museums in no condition for botanical determination.

B. L. R.

Recent Contributions to Morphology of the Higher Plants.[1] — The high standing of Professor Goebel and his many important contributions to the morphology of the higher plants makes the present work of great interest to botanical students everywhere. The volume at hand is the first of a series which promises to give a comprehensive summary of what may, perhaps, be termed "developmental morphology," which seems to be about what Goebel means by Organography.

This first volume deals with general Organography, or a general consideration of the members which make up the vegetable organism, their origin and modifications. In the preface attention is called to the great changes which have taken place in regard to morphological questions. The old idealistic conception of "morphologically equivalent" organs as structures which are patterned after an imaginary "type" has been replaced by the idea of homologous structures which are really genetically related. Goebel also insists, and very justly, that no sound system of morphology can be based upon the use of a single character, but that all factors must be taken into account; and, as has already been pointed out by him in his previous studies, the impossibility of divorcing absolutely morphology and physiology is here emphasized. In his zeal as to the importance of determining the causes which directly influence plants as they at present exist, he is perhaps a little too severe on those botanists who

[1] *Organographie der Pflanzen, Erster Teil, Allgemeine Organographie.* Dr. K. Goebel, Professor of Botany in the University of Munich. Jena, Gustav Fischer, 1898.

yield to the fascination of phylogenetic studies. When, for example, he says, "It seems to me that the recognition of the factors which make one side of a leaf larger than the other is of more importance than the building up of a phylogenetic structure from unsupported hypotheses," there is an implication of the futility of *all* phylogenetic speculation which we feel is scarcely warranted.

While the first section of the book ("Allgemeine Gliederung des Pflanzenkörpers") takes into account the morphology of the Thallophytes, the rest of the work is confined to a discussion of the Archegoniates and Spermatophytes. The question of the province of morphology is treated at length, and very clearly, in the first section. The impossibility of clearly separating structure and function is emphasized, and the difficulties in absolutely distinguishing homologies and analogies are pointed out. As he very clearly shows, it is perfectly evident that the same result has been brought about in much the same way in widely divergent stocks. For instance, while the leaves of such an anacrogynous liverwort as Fossombronia, and those of an acrogynous form like Jungermannia are doubtless homologous in the sense that they bear the same relation to the apical cell of the shoot, nevertheless there is every reason to believe that they have developed quite independently of each other.

In classifying the fundamental organs of plants, Goebel divides them first into two categories, vegetative and reproductive organs. In view of the difficulties of limiting the definitions of stem (caulome) and leaf (phyllome) in the vascular plants, our author regards these as modifications of a common fundamental structure, the shoot (Spross), while the root is the second of the two primary vegetative structures. Hairs (trichomes) and "emergences" are considered as appendages merely of the two fundamental structures. While, of course, the stem and leaves of the higher seaweeds and mosses are recognized as not being the homologues of those of the vascular plants, still Goebel does not think it best to adopt new names for these structures.

The second group of fundamental structures, the reproductive organs, are of two kinds, sporangia (or sporogonia) and sexual organs, antheridia and archegonia (or oögonia). Goebel was perhaps the first botanist to show that the sporangia of the ferns, for instance, are in no proper sense to be considered as modifications of structures once vegetative in nature, but that they, as well as the sexual organs, must be considered as fundamental structural types. The whole trend of the conclusions, based upon the most recent study of the

archegoniates, is that the sporogenous structures of the sporophyte are older than the vegetative ones.

The discussion of the division of labor and development of special organs in the Thallophytes is treated clearly and interestingly, but offers nothing especially new.

The section dealing with the question of cohesion and reduction of parts is clearly presented, and Goebel, like most students who have made a practical study of developmental morphology, recognizes the absurdity of assuming that all simple flowers such as many apetalous Dicotyledons and the lower Monocotyledons like the Araceæ and Naiadaceæ are necessarily reduced from some forms with more complex flowers — a relic of the old metaphysical notion of a "typical flower" to which all other types must be made to conform.

The second division of the volume deals with the question of symmetry in the plant-body. It is treated at length and the author brings up many interesting points, especially those dealing with the causes and significance of bilaterality or dorsi-ventral symmetry in shoots and leaves, as well as zygomorphy in flowers. In regard to the latter point, he concludes that we are not much nearer to understanding the mechanism by which they have been produced than were Sprengel and De Candolle. All we know is that they are in most cases associated with cross-fertilization, and that zygomorphic flowers are always lateral in origin.

The most interesting part of the book is the portion dealing with the changes in the character of the organs of the plant, especially the leaves, as the plant develops from its earlier stages to maturity. Goebel has already published several very important contributions to this most interesting subject, but he adds here a good deal that has not before appeared, and at the same time includes a summary of the more important results of his earlier investigations, especially with regard to the changes in the form of leaves and the significance of these early leaf-forms. Perhaps the most important of the new types brought forward here is that of certain tropical Aroids, especially some of the climbing forms. These striking plants are very conspicuous in the American tropics. Goebel made a special study of some of these and found that in their earlier stages of growth they had simple, sessile leaves, closely overlapping and completely concealing the stem. The flowering shoots, however, lose the dorsiventral character, and the much larger and often variously cut leaves, *e.g.*, Philodendron, are borne upon long petioles. It appears that

these immature forms have been propagated in greenhouses under various names, "Pothos," "Marcgravia,"—very much as the early shoots of Thuja, with the needle-shaped leaves, were for so long supposed to belong to a special genus, Retinospora.

The reversion to the primitive leaf-forms in the seedlings and sometimes in older shoots of various water-plants and xerophytes is discussed at length, and their bearing upon the questions of the origin and affinities of these plants is admirably set forth.

The fourth division of the work deals with malformations of various kinds, discussing in a very suggestive way their cause and significance. Goebel believes that the explanation of Sachs, who assumes that specific chemical substances are developed which determine the character of the various organs, is the most plausible one yet brought forward. Goebel's explanation of the reason why malformations, especially the transformation of one organ into another, are so much commoner in the flowers than in the other organs of the plant, *e.g.*, the roots, is because the young organs of the flower are formed in rapid succession, and close together, so that the specific substances properly belonging to one organ are more likely to reach one of another kind, thus producing a more or less transitional form. To quote from our author: "If, for instance, molecules of such substances as induce anther-formation should stray even by the thousandth part of a millimeter from their path, or should be checked or hastened in their transportation to the growing point of the flower, there would thus result a more or less complete transformation of the petals or carpels into stamens."

Goebel also quotes from Sachs to show that the latter conceives these "blütenbildende" substances to have somewhat the character of ferments, an extremely small quantity having power to affect large masses of plastic substance. A similar character is attributed by Beyerinck to what he calls "growth enzymes," produced by gall-forming insects, which so affect the protoplasm of the host-plant as to give rise to the specific gall-form.

While these theories are certainly interesting and not improbable, they seem quite as difficult to prove as the phylogenetic hypotheses, which Goebel in another part of his work seems to think so hopeless.

The last division of the book has to do with the influence of correlation and external stimuli upon the form of the vegetable organism, and presents many interesting details which cannot here be discussed at length.

Every botanist who is interested in morphological problems must

feel grateful to Professor Goebel for the admirable manner in which he has presented them, and all will look forward eagerly to the appearance of the subsequent volumes, which we hope may not be long delayed.

DOUGLAS HOUGHTON CAMPBELL.

STANFORD UNIVERSITY,
May, 1898.

MINERALOGY.

Genesis of the Diamond. — Derby[1] has sifted the evidence of the Brazilian deposits bearing on the puzzling and as yet unsolved problem of the origin of the diamond. Three localities are discussed, of as many types.

At the Agua Suja mine, in western Minas Geraes, the diamond-bearing bed is a decomposed conglomerate, both matrix and pebbles having been transformed into clay. The fragments can, however, still be recognized as belonging to the various schists, granites, and sandstones upon which the bed rests, and to basic eruptives, probably members of the nepheline-bearing series of rocks of the region. Weight is placed upon these basic eruptives as suggesting an analogy with the South African deposits; on the whole, however, the differences are more striking than the similarities. The diamond is evidently contained in the cement, not in any constituent of the breccia, and its source cannot even be conjectured with any degree of certainty.

In the mines of Diamantina and those of Grao Mogõl, all in Minas Geraes, which are the oldest and best known of the Brazilian fields, the diamonds occur in a quartzose rock known as itacolumite. There are two types of this rock, a schistose form, and a massive variety which the writer believes is clearly clastic, and later than the schistose form, resting unconformably upon it. Probably both types of the rock are clastic, but both are largely metamorphosed, and it is impossible to say whether the diamond is a local product of that metamorphism or was introduced as a clastic element.

The third locality described is the mine at São João Chapada, near Diamantina. The description is very full, the place having never been described before, as its interest demands. It consists of a huge open pit, in a mass of clay produced by the complete decomposition of the country rocks. The clays may be differentiated

[1] Brazilian Evidence on the Genesis of the Diamond. *Journ. of Geol.*, vol. vi, p. 121.

roughly by variety of color into three horizons, or rather bodies, as their shape is irregular, in each of which diamonds are said to have been found. A careful consideration of the materials of these various clays leads the author to consider that they represent an original group of phyllites of varied character, but chiefly of clastic origin, threaded with veins of pegmatite, and possibly containing some eruptive material of more basic character. Assuming the correctness of this analysis of this very obscure and difficult problem of "mud-geology," it becomes desirable to know, first, whether the pegmatite was eruptive and may have exercised a metamorphic action upon the schists, or was secretionary; second, whether the diamond belongs to the pegmatite or to the country rock. The first question the writer decides in favor of the eruptive hypothesis, although the evidence is not conclusive. The second he considers it necessary to leave an open one, but the indications seem to favor the view that the diamonds were formed in the phyllites on the border of the pegmatites and presumptively through the agency of their eruptive action, the phyllites having provided the carbon which is shown to be amply sufficient.

Etching Figures of Triclinic Minerals.[1] The writer has investigated several triclinic minerals by the etching method for the purpose of determining whether they possessed the holohedral centro-symmetry of that system. His experiments on tourmaline (hexagonal, hemimorphic) and on cleavage plates of acid dextro-tartrate of strontium (triclinic, hemihedral) showed that the etching figures produced on two parallel crystal faces of unlike physical character were distinctly different, sufficiently so to be used as a safe means of determining such unlikeness. The tests recorded were made upon the following minerals, the result in all cases being confirmatory of their accepted holohedral character: axinite, cyanite, copper sulphate (artificial crystals), rhodonite, albite. On the tourmaline and cyanite the etching was produced by the action of a fusing mixture of acid potassium sulphate and fluorite, on the others by a mixture of equal portions of sulphuric and hydrofluoric acids. The results add to our knowledge of the etching figures of some of the minerals named, although negative as far as concerns the point investigated.

Clinohedrite, a New Mineral from Franklin, N. J.[2] — The new mineral was first found by Mr. Nason some two years ago, but more

[1] Walker, T. L. *Amer. Journ. of Sci.*, vol. v, p. 176, 1898.

[2] Penfield, S. L., and Foote, H. W. *Amer. Journ. of Sci.*, vol. clv, p. 289, 1898.

recent finds of better material have first made a complete description possible. But few specimens in all have yet been found, all coming from the Trotter mine, at a supposed depth of about one thousand feet. It is associated with willemite, massive brown garnet, phlogopite, axinite in small crystals, datolite, and a reddish-brown mineral occurring in slender prismatic crystals, whose investigation is not yet complete, but which proves to be a new silicate containing lead, iron, and calcium as essential constituents.

The name of the new mineral, clinohedrite, is suggested by the prevalence of forms having no parallel faces. It is monoclinic in crystallization, and of special interest as belonging to the hemihedral division of that system, the "domatische klasse" of Groth, hitherto represented among mineral substances only by occasional crystals of pyroxene, which, however, seems to be normally holohedral. The crystals were well suited to measurement, upwards of 4 mm. in greatest dimension, and of two types.

The axial ratio is as follows: $a:b:c = 0.6826:1:0.3226$, $\beta = 76° 4'$.

Forms observed:

b, 010	n, 120	p, 111	r, $\bar{3}31$	o, $\bar{1}31$
h, 320	l, 130	p_1, $\bar{1}1\bar{1}$	s, $\bar{5}51$	o_1, $13\bar{1}$
m, 110	e, 101	q, $\bar{1}11$	t, $\bar{7}71$	x, $\bar{1}3\bar{1}$
m_1, $\bar{1}10$	e_1, $\bar{1}0\bar{1}$	q_1, $11\bar{1}$	u, $\bar{5}31$	y, $\bar{1}2\bar{1}$

Cleavage perfect parallel to b, 010, hardness 5.5, specific gravity 3.33.

Many crystals are transparent, the color varying from amethystine to colorless or white. Double refraction negative and not very strong. Plane of optic axes at right angles to 010; the crystallographic axis b, the acute bisectrix. Exhibits distinctly the phenomena of pyro-electricity, the faces p, e and upper extremities of m becoming, on cooling, positively electrified, the diagonally opposite faces, x, y, p, e, negatively. Chemical composition:

SiO_2	ZnO	MnO	CaO	MgO	H_2O	$(Fe.Al)_2O_3$	Sum
27.22	37.44	0.50	26.25	0.07	8.53	0.28	100.32

corresponding to the formula $H_2Zn\,Ca\,SiO_5$ or $(ZnOH)\,(CaOH)\,SiO_3$, analogous to that of calamine $(ZnOH)_2\,SiO_3$.

Pyrognostics: in closed tube, unchanged at low heat, at faint redness exfoliates, whitens, and gives off water. Fuses at 4 to a yellowish enamel. Soluble with gelatinization in HCl.

Rhodolite, a New Variety of Garnet.[1] — Under this name a variety of garnet is described which occurs in placer deposits in Macon County, North Carolina, and is notable for its fine amethystine and rose color, and gem quality of clearness. It occurs only in rolled or etched fragments, together with the following minerals, in more or less abundance: quartz, pyrope, corundum, spinel, iolite, cyanite, fibrolite, hornblende, staurolite, rutile, chromite, monazite, zircon, gold, sperrylite, menaccanite, and bronzite.

The specific gravity of the material which was very free from inclusions was 3.838. Chemical composition:

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Sum
41.59	23.13	1.90	15.55	17.23	0.92	100.32

corresponding to the formula $2Mg_3\ Al_2\ (SiO_4)_3.Fe_3Al_2\ (SiO_4)_3$, a mixture of two pyrope molecules with one of almandine.

PETROGRAPHY.

Classification of Igneous Rocks. — In an interesting paper on the relation between the chemical and mineral composition of igneous rocks, Iddings[2] shows very plainly that the mineral composition of a cooling magma is dependent both on the original composition of this magma and upon the character of the minerals that *first* separate from it. It is well known that quartz is usually associative only with the polysilicate-feldspathic minerals. Of these minerals the most acid one possible with the available silica in the magma, is that which forms first. The alkalies seem to control an equal amount of alumina, forming alkali-feldspathic molecules, the alumina in excess combining with calcium to form anorthite, or with magnesium and iron to produce the amphiboloids. These and several other laws less firmly established have been carefully worked out by comparing the mass composition of massive rocks with their mineral composition. The author discusses in detail the mineral composition of magmas (1) in which the alkali is wholly soda and in which alumina is present in equivalent quantities with the soda; (2) those in which the sole alkali is potash with alumina in equal quantity; and (3) those in which the alkalies control an equal amount of alumina and in which lime and additional alumina occur in the proportion of

[1] Hidden, W. E., and Pratt, J. H. *Amer. Journ. of Sci.*, vol. clv, p. 294, 1898.
[2] *Journ. of Geol.*, vol. vi, p. 219.

1 to 1. The results of the investigations are exhibited in several diagrams, which show in a remarkable manner the relations between the chemical and the mineral composition of a large number of rocks.

California. — Massive flows of a rock intermediate in composition between trachytes and andesites are associated with the andesitic tuffs and breccias in the Sonora and Big Trees quadrangles of the Sierra Nevada, California. The rocks, according to Ransome,[1] are characterized by a high percentage of alkalies with potash in excess of soda. The author describes them under the name latite, possessing large phenocrysts of plagioclase and a few anhedra of pale-green augite in a compact aphanitic base. Under the microscope idiomorphic olivines are also discovered. The groundmass is a hyalopilitic aggregate of labradorite, augite, and a globulitic glass, magnetite, and apatite. Biotite phenocrysts are present in some specimens. The fact that the analyses of all specimens show the presence of considerable potash, while at the same time no potash-bearing mineral has been observed in them, suggests that the residual glass is very rich in this oxide. Analyses of the augite-latite from Tuolumne, Table Mt., and of the biotite-augite-latite from near Clover Meadow follow:

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	P_2O_5
Aug.-latite	56.19	.64	16.76	3.05	4.18	3.79	6.53	2.53	4.46	1.00	.55
Biot.-au.-latite	62.33	1.05	17.35	2.98	1.63	1.05	3.23	4.21	4.46	1.19	.29

besides small quantities of MnO, BaO, SO_2, Li_2O, and C.

These rocks are the effusive equivalents of the monzonites. They differ from andesites in possessing a large percentage of the alkalies with potash predominating. They differ from trachytes in containing no sanidine. They are closely related to the vulsinites, ciminites, and other rock types described abroad. The term latite is proposed to include all the effusive forms of monzonite, leaving vulsinite, ciminite, etc., as terms for varietal forms. It is nearly equivalent to Washington's term trachy-dolerite. The dike rocks corresponding to the latites may be the banakites of Iddings.

Nodular Granite, Ontario. — A peculiar occurrence of nodular granite has been found by Adams[2] in the township of Cardiff, Peterborough County, Ontario. The granite is a fine-grained reddish rock banded by streaks of different degrees of coarseness. The nodules are spherical or elliptical, with diameters varying from one

[1] *Amer. Journ. of Sci.*, vol. v, p. 355, 1898.
[2] *Bull. Geol. Soc. Amer.*, vol. ix, p. 163.

to eight inches. Their nuclei are usually lighter in color than their peripheral portions, and contain often little bunches of tourmaline and plates of muscovite. In some places the nodules are arranged in rows. Sometimes the nodules of a row coalesce and pass into a continuous band with all the properties of a vein. Through the veins are scattered bunches of tourmaline, like those in the centers of the nodules: and the central portion of the vein, like the nuclei of the nodules, is composed of feldspar and muscovite. Its periphery, like the peripheries of the nodules, consists principally of quartz and sillimanite. Analyses of the granite (I) and the nodules (II) show the latter to be the more siliceous and the less alkaline.

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	Loss	Total
I	78.83	10.88	1.63	.22	.35	5.31	2.13	.32	= 99.67
II	81.43	13.70	1.58	.37	.06	1.28	1.02	.92	= 100.36

From a consideration of the manner of occurrences of the nodules and their composition when compared with the granite, Adams concludes that they were derived from the crystallization of a magma which was free to gather itself into rounded drop-like forms which the isolated portions of such a liquid would take, but which could not be developed in a magma when crystallization was far advanced.

The rock of the Great Whin Sill in Durham and Northumberland has profoundly altered the carboniferous limestones, shales, and sandstones with which it is in contact. Hutchings[1] declares that the pure limestones have simply suffered crystallization except in the immediate contact with the eruptive where garnets have sometimes been produced. The eruptive, on the other hand, has had developed in it both small garnets and small flakes of a brown biotite. Argillaceous limestones have suffered a great deal more change than the purer limestones. The new contact minerals found in them are garnet, augite, idocrase, wollastonite, epidote, hornblende, feldspar, chlorite, and sphene. The shales have become indurated. Chlorite and muscovite have been formed in large quantity and "spots" have developed. In many of the shales, especially sandy varieties, much of the quartz has recrystallized, feldspar has been produced, and the characteristic contact minerals, andalusite, biotite, anthophyllite, etc., have originated. The calcareous shales are the most intensely altered of all the beds in the district. They yield a hornfels filled with garnets, idocrase, spinel, wollastonite, and, in short, all the other minerals characteristic of the altered argillaceous limestones and the shales.

[1] *Geol. Magazine*, vol. v, pp. 69, 123, 1898.

After discussing a large number of analyses of the altered and the unaltered rocks, the author concludes that it cannot be proved that transfer of soda from the igneous rock to the sedimentary ones has taken place. The paper closes with a protest against ascribing to dynamic-metamorphism many of the effects that may be due to contact action.

Notes. — The "porphyritic gneiss" of New Hampshire, formerly supposed by Hitchcock and others to be a Laurentian metamorphosed sediment, is shown by Daly[1] to be an igneous rock intruded into the surrounding rocks in post-Devonian time. Iwasaki[2] mentions the existence of a diorite dike cutting the Tertiary rocks in the Usui Pass, near Tokio, Japan. It consists of zonal plagioclase, hornblende, quartz, and several accessory and secondary constituents. The author calls it an andendiorite, following Stelzner, who has described a quartz-bearing mica diorite occurring in a "neovolcanic dike" in Argentine.

Two interesting examples of contact action are described by D'Achiardi.[3] The first is between dolomite, on the one hand, and granite and diabase on the other, near Berdiaouch in the Ilmen Mountains, Russia, and the second between limestone and granite on the Isle of Elba. The new minerals produced in the limestones by the contact action are not essentially different from those occurring under similar conditions elsewhere. The development of antigorite, pyroxene, wollastonite, and white mica is especially prominent.

W. S. BAYLEY.

[1] *Journ. of Geol.*, vol. v, pp. 694, 776. [2] *Ib.*, vol. v, p. 821.
[3] Atti della Soc. Tosc. d. Sci. Nat. Pisa. *Memoire*, vol. xvi.

SCIENTIFIC NEWS.

THE University of St. Andrews, Scotland, is to establish professorships of physiology, anthropology, and anatomy.

The Botanical Club of Barnard College has transferred $500 to the college as the nucleus of a fund for the equipment of a botanical laboratory to be named in memory of the late Prof. Emily L. Gregory.

The College of Physicians of Philadelphia announces the first Hatfield prize competition. The subject is "A pathological and clinical study of the thymus gland and its relations." Competing essays must be in the hands of the committee on or before Jan. 1, 1900.

The *Journal of the Marine Biological Association*, England, contains in its April number a description of an apparatus for keeping medusæ alive in the aquarium. It was found that medusæ, to live, must float at the surface, and in ordinary aquaria they can only do this by constant pulsations of the umbrella. This severe and constant strain resulted in physical exhaustion and death. The apparatus consists of an automatic plunger which creates currents in the water, and by its aid specimens were kept alive for six weeks.

Mr. N. B. Harrington and Mr. Reid Hunt, of Columbia University, have gone to the west coast of Africa in the hope of obtaining material upon the embryology of Polypterus, one of the two existing corsopterygian ganoids, and one of the most interesting of vertebrates, since by many — Pollard, Cope, Kingsley, Dollo, and others — they are regarded as being the nearest to the ancestors of Amphibia and hence of the aminotes. The expedition has received $1800 from Mr. Charles F. Senf.

Prof. C. L. Bristol, of New York University, goes with a party of students to the Bermudas, where he spent last year. It is proposed to erect a permanent station there, but probably not this year.

An important step is probably to be taken in London in the removal of the collections of the geological survey from their crowded quarters in Jermyn Street to South Kensington.

At last the University of Oxford is to have a respectable morphological laboratory. Prof. E. Ray Lankester was appointed to the university in 1891, and during these years his work has largely been conducted in a small one-story building constructed of corrugated iron, affording quarters far inferior to those in the average American college. The university is now to expend not more than $35,000 in removing the old building and in erecting on its site a laboratory and a lecture room for the chairs of botany and comparative anatomy.

The Russian Society of Naturalists and Physicians holds its tenth congress at Kieff from August 21 to August 30.

Money is being collected for a monument to the memory of the late Baron Ferdinand von Müller, who did so much for Australian natural history.

The Imperial Museum of Japan has just issued a preliminary catalogue of the collection of fishes *sensu latior* in its possession. The catalogue is compiled by Dr. Ischikawa and Mr. Matsuura, and enumerates 1076 specimens. The localities for each are given in Japanese except for those coming from extra-Japonic waters. The collection is almost exclusively Japanese, *Balistes vetula*, *Anicurus nebulosus*, and *Lepidosteus osseus* being the only American representatives. No specimens of Chlamydoselachus are catalogued, nor are there any Japanese species of Amphioxus included, although Nakagawu has recently described a form from Japanese waters.

The fresh-water sponges *Ephydatia obusta* and *Carterius tubisperma* described by Edward Potts from American waters have just been found by Garbini in the Garda Sea of Northern Italy.

The following information teaches us concerning the Geological and Natural History Survey of Wisconsin: Mr. Weidman is now in the field, completing the field work on an area of the older rocks in the vicinity of Wausau and Merrill, in the northern part of the state. This work will be continued during the summer. Mr. Buckley has been at work at a large report upon the building-stone industry of the state. This will probably be ready for the printer during the summer.

The following work is planned for the season: Prof. R. D. Salisbury, of Chicago University, and an assistant, will complete the work necessary to the preparation of a bulletin on the physical geography

and geology of the region about Devil's Lake and the dells of the Wisconsin River. Prof. G. L. Collie, of Beloit, will complete the preparation of a general account of the physical geography of southern Wisconsin, the field work for which was nearly completed last season. Prof. D. P. Nicholson will work at physical geography, probably in the northern part of the state. Prof. L. S. Cheney is preparing a popular report on the forest trees of the state. Prof. E. A. Birge, of the State University, and Prof. C. D. Marsh intend to carry on their studies of the plankton of the lakes in the central and southern parts of the state. The Survey has two bulletins in type: one by Filibert Roth, of the United States Department of Agriculture, upon the forest conditions of the state, and one by Dr. and Mrs. G. W. Peckham, on the habits and instincts of the solitary wasps. Mr. S. Weidman has ready for publication a bulletin on certain volcanic rocks in the Fox River Valley.

The following appointments to fellowships are announced: at Columbia University, botany, E. Hagen; geology, J. D. Irving; zoölogy, F. C. Paulmier; psychology, R. S. Woodworth. At Johns Hopkins University: physiology, P. M. Dawson; geology, L. C. Glenn; zoölogy, G. O. James. Tufts College: biology, S. P. Capen.

The last annual report of the British Museum shows that the number of visitors to the Natural History Museum during 1896 was 417,033 on week days and 36,923 on Sundays, making a total of 453,956 as compared with 446,737 (on week days only) in the year 1895. The average attendance for all open days, including Sundays, during the year was 1316; that for week days only, 1336, as compared with 1436 in 1895, thus making the average week-day attendance 150 less in 1896 than in 1895. The museum was opened for the first time on Sunday, on May 17, 1896, and the figures would seem to indicate that after the inauguration of the Sunday openings, daily, at least 100 visits were postponed until Sundays; and that owing to the Sunday opening, there was, in little more than half a year, a net gain of 7219 visitors to the museum.

Recent appointments: B. M. Duggar, instructor in botany in Cornell University. — Dr. J. E. Durand, reappointed instructor in botany in Cornell University. — Dr. Fischer, docent in anatomy in the German University at Prague. — W. J. Gies, instructor in physiology at Yale. — E. S. Goodrich, demonstrator of anatomy in Oxford University. — Dr. Karl Hischeler, private docent in zoölogy

in the University of Zurich. — Professor Kalkowsky, director of the Mineralogical, Geological, and Ethnological Museum at Dresden. — Gräfin Maria von Linden, second assistant in zoölogy in the University of Tübingen. — Dr. William Pollard, assistant petrologist of the Geological Survey of Great Britain, at Jermyn Street, London. — H. J. Seymour, assistant petrologist of the Geological Survey of Great Britain, at Dublin. — Prof. Herbert Osborn, formerly of the Iowa Agricultural College, has been appointed to the chair of zoölogy at Ohio State University, left vacant by the death of Professor Kellicott. — Dr. C. O. Townsend, formerly instructor in botany at Barnard College, has recently been elected botanist and plant pathologist for the state of Maryland. — C. B. Wedd, assistant geologist of the Geological Survey of Great Britain. — K. M. Wiegand, assistant in botany in Cornell University. — Dr. E. Zacharias, director of the Botanical Gardens at Hamburg.

Recent deaths: Maurice Hovelacque, secretary of the Geological Society of Paris. — Dr. C. Herbert Hurst, zoölogist, formerly of Owens College, Manchester, and more recently demonstrator in zoölogy in the Royal College of Science, Dublin. — W. C. Lucy, an English geologist, May 11, aged 75. — W. M. Maskell, entomologist in New Zealand. — Prof. Friedrich Müller, ethnologist, of Vienna, May 25, aged 64. — Edward Wilson, curator of the museum at Bristol, England, May 21, aged 49.

PUBLICATIONS RECEIVED.

Biological Lectures Delivered at the Marine Biological Laboratory of Woods Holl. 1896–97. Boston, Ginn & Company. 242 pp., 8vo. Illustrated. $2.15. — DETMERS, W. Practical Plant Physiology. An Introduction to Original Research for Students and Teachers of Natural Science, Medicine, Agriculture, and Forestry. Translated from the second German edition by S. A. Moor. London, Swan Sonnenschein & Co., 1898. xix + 555 pp., 8vo, 184 illustrations. $3.00. — NEEDHAM, JAS. J. Outdoor Studies. A Reading-Book of Nature. American Book Co., 1898. 90 pp., 8vo, 88 figs. — *Report of the Commissioner of Education, 1896–97.* Vol. i, Pt. i. Washington, 1898. 1136 pp., 8vo. — SARS, J. O. An Account of the Crustacea of Norway. Vol. ii. Isopoda. Pts. ix, x. Munnopsidæ (concluded), Ligiidæ, Trichoniscidæ, Oniscidæ. Bergen, The Bergen Museum, 1898. Pp. 145–184, Pls. 66–88.

Botanical Gazette. Vol. xxv, No. 6, June. — *Current Thought.* New series, Vol. i, No. 3, July. — *Geological and Natural History Survey of Minnesota.* Second series, Pt. i, June. Minnesota Botanical Studies. — *Verhandlungen der russisch-kaiserlichen mineralogischen Gesellschaft zu St. Petersburg.* Zweite serie, Bd. xxxiv, Lief. ii, 1896. Bd. xxxv, Lief. i, 1897. — *Materialen zur Geologie Russlands.* Herausgegeben v. d. kaiserlichen mineralogischen Gesellschaft. Bd. xviii, 1897. — *Verhandlungen der kaiserlichen mineralogischen Gesellschaft zu St. Petersburg.* Systematisches Sach- und Namen-Register z. d. zweiten Serie d. Verhandlungen u. den Materialen zur Geologie Russlands. 1898. — *Knowledge.* Vol. xxi, No. 153, July. — *Michigan State Agricultural College Experiment Station.* Bulletins 157, 158, Hog Cholera and Some Experiments with Poultry. May. Elementary Science Bulletin No. 4. Observations on the Leaves of Clovers at Different Times of Day, by J. J. W. Beal. May. — *Naturen.* Aarg. 22, No. 5, May. Bergen, John Grieg. — *North Carolina Agricultural Experiment Station.* Bulletins 147 and 148, June, 1898. A Study of Lettuces, by W. F. Massey; Digestion Experiments, by F. E. Emery and B. W. Kilgore; Pasteurization of Milk, by F. E. Emery. — *Proceedings Natural Association of Staten Island.* Vol. vi, No. 8, June. — *Société Scientifique du Chili.* Actes, Tome vii (1897), Liv. 5. Santiago, April, 1898. — *The Zoölogist.* Fourth series, Vol. ii, No. 18, June.

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A HALF-CENTURY OF EVOLUTION, WITH SPECIAL REFERENCE TO THE EFFECTS OF GEOLOGICAL CHANGES ON ANIMAL LIFE.[1]

ALPHEUS S. PACKARD.

ONLY a little less than fifty years have passed since the publication of Darwin's *Origin of Species*, and the general acceptance by naturalists of the theory of descent. Since 1848 the sciences of embryology, cytology, and comparative anatomy based on embryology, or, as it is now called, morphology, have been placed on a firm foundation. It is but little over half a century since the uniformitarian views of Lyell were promulgated. The cell doctrine was born in 1839; the view that protoplasm forms the basis of life was generally received forty years since; fifty years ago the doctrine of the conservation of forces was worked out, and already by this time had the idea of the unity of nature dominated the world of science.

On the fiftieth anniversary, therefore, of our Association it may not be out of place, during the hour before us, first, briefly

[1] Address of the Vice-President and Chairman of Section F, Zoölogy, at the fiftieth anniversary meeting of the American Association for the Advancement of Science, Boston, August, 1898.

to inquire into the present state of evolution and its usefulness to zoölogists as a working theory, and then to dwell more at length on the subject of the effect of geological changes on animal life.

The two leading problems which confront us as zoölogists are: What is life? and How did living beings originate? We must leave to coming centuries the solution of the first question, if it can ever be solved; but we can, as regards the second, congratulate ourselves that, thanks to Lamarck, Darwin, and others, in our day and generation a reasonable and generally accepted solution has been reached.

Time will not allow us to attempt to review the discoveries and opinions which have already been discussed by the founders and leaders of the different schools of evolutionary thought, and which have become the common property of biologists, and are rapidly permeating the world's literature.

It may be observed at the outset that, if there is any single feature which differentiates the second from the first half of this century, it is the general acceptance of the truth of epigenetic evolution as opposed to the preformation or incasement theory, which lingered on and survived until a late date in the first half of the present century.[1] The establishment of the

[1] The theory of incasement (*emboîtement*), propounded by Swammerdam in 1733, was that the form of the larva, pupa, and imago of the insects preëxisted in the egg, and even in the ovary; and that the insects in these stages were distinct animals contained one inside the other, like a nest of boxes, or a series of envelopes one within the other; or, in his words: "Animal in animali, seu papilio intra erucam reconditus." Réaumur (1734) also believed that the caterpillar contained the form of the chrysalis and butterfly, saying: "Les parties des papillon cachées sous le fourreau de chenille sont d'autant plus faciles à trouver que la transformation est plus proche. Elles y sont néanmoins de tout temps." He also believed in the simultaneous existence of two distinct beings in the insect. "Il serait très curieux de connaître toutes les communications intimes qui sont entre la chenille et le papillon. . . . La chenille hache, broye, digère les aliments qu'elle distribué au papillon; comme les mères préparent ceux qui sont portés aux fœtus. Notre chenille en un mot est destinée à nourrir et à défendre le papillon qu'elle renferme." (Tome i, 8e Mémoire, p. 363.)

It was not until 1815 that Herold exploded this error, though Kirby and Spence in 1828, in their *Introduction to Entomology*, combated Herold's views and maintained that Swammerdam was right. As late as 1834, a century after Swammerdam, Lacordaire in his *Introduction à l'Entomologie*, declared that "a caterpillar is not a simple animal, but compound," and he actually goes so far as to say that

epigenetic view is largely due to exact investigation and modern methods of research, but more especially to the results of modern embryology and to the fairly well digested facts we now have relating to the development of one or more types of each class of the animal kingdom.

To use a current phrase, the evolution theory as now held has come to stay. It is the one indispensable instrument on which the biologist must rely in doing his work. It is now almost an axiomatic truth that evolution is the leaven which has leavened the whole lump of human intellectual activity. It is not too much to claim that evolutionary views, the study of origins, of the beginning of organic life, the genesis of mental phenomena, of social institutions, of the cultural stages of different peoples and of their art, philosophy, and religion, — that this method of natural science has transformed and illuminated the philosophy of the present half-century.[1]

"a caterpillar at first scarcely as large as a bit of thread, contains its own teguments threefold and even eightfold in number, besides the case of a chrysalis, and a complete butterfly, all lying one inside the other." This view, however, we find is not original with Lacordaire, but was borrowed from Kirby and Spence without acknowledgment. These authors, in their *Introduction to Entomology* (1828), combated Herold's views and stoutly maintained the old opinions of Swammerdam. They based their opinions on the fact, then known, that certain parts of the imago occur in the caterpillar. On the other hand, Herold denied that the successive skins of the pupa and imago existed as germs, holding that they are formed successively from the *rete mucosum*, which we suppose to be the hypodermis of later authors. In a slight degree the Swammerdam-Kirby and Spence doctrine was correct, as the imago does arise from germs, *i.e.*, the imaginal discs of Weismann, while this was not discovered by Herold, though they do at the outset arise from the hypodermis, his *rete mucosum*. Thus there was a grain of truth in the Swammerdam-Kirby and Spence doctrine, and also a mixture of truth and error in the opinions of Herold.

The discovery by Weismann of the imaginal discs or buds of the imago in the maggot of the fly, and his theory of histolysis, or of the more or less complete destruction of the larval organs by a gradual process, and his observation of the process of building up of the body of the imago from the previously latent larval buds, was one of the triumphs of modern biology. It is therefore not a little strange to see him at the present day advocating a return to the preformation views of the last century in the matter of heredity. Of course it goes without saying, as has always been recognized, that there is something in the constitution of one egg which predestines its becoming an insect, and in that of another which destines it to produce a chick.

[1] It is worthy to mention that just fifty years ago, in his *Future of Science*, written in 1848, at the age of 25, Renan, who first among philosophers and stu-

It is naturally a matter of satisfaction and pride to us as zoölogists that, though evolution has been in the air from the days of the Greek philosophers down to the time of Lamarck, the modern views as to the origin of variations, of adaptation, of the struggle for existence, of competition, and the preservation of favored organs or species by selection, are the products of single-minded zoölogists like Darwin, Wallace, Fritz Müller, Semper, and Haeckel. It is the work of these men, supplemented by the labors of Spencer and of Huxley, and the powerful influence of the botanists Hooker and Gray, all of whom contributed their lifelong toil and efforts in laying the foundation stones of the theory, which has brought about its general acceptance among thinking men. It is these naturalists, some of them happily still living, who had worked out the principle of evolution from the generalized to the specialized, from the simple to the complex, from chaos to cosmos.

The doctrine of evolution has been firmly established on a scientific basis by many workers in all departments of biology, and found not only to withstand criticism from every quarter, but to be an indispensable tool for the investigator. The strongest proof of its genuine value as a working theory is that it has, under the light shed by it, opened up many an avenue of inquiry leading into new fields of research. It is based on the inductive method, the observation and arrangement of a wide series of facts. Moreover, it explains a vast

dents of comparative philology adopted the scientific method, *i.e.*, the patient investigation of as wide a range of facts as possible, wrote: "I am convinced that there is a science of the origins of mankind, and that it will be constructed one day, not by abstract speculation, but by scientific researches. What human life in the actual condition of science would suffice to explore all the sides of this single problem? And still, how can it be resolved without the scientific study of the positive data? And if it be not resolved, how can we say that we know man and mankind? He who would contribute to the solution of this problem, even by a very imperfect essay, would do more for philosophy than by half a century of metaphysical meditation" (p. 150). Again he says: "The great progress of modern thought has been the substitution of the category of *evolution* for the category of the *being*; of the conception of the relative for the conception of the absolute, of movement for immobility. Formerly everything was considered as 'being' (an accomplished fact); people spoke of law, of religion, of politics, of poetry in an absolute fashion. At present everything is considered as in the process of formation" (p. 169).

complex of facts, and enables us to make predictions, the true test of a scientific theory. Biology is not an exact science, hence the theory is not capable of demonstration like a problem in mathematics, but is based on probabilities, the circumstantial evidence being apparently convincing to every candid, well-trained mind.

The methods and results of natural science, based as they now are on evolutional grounds, have, likewise, appealed to the historian, the philologist, the sociologist, and the student of comparative religion, whose labors begin with investigations into the origins.

It goes without saying that, thanks to the initiative of the above-named zoölogists, every department of intellectual work and thought has been rejuvenated and rehabilitated by the employment of the modern scientific method. All inquiring minds appreciate the fact that, throughout the whole realm of nature, inorganic as well as organic, physical, mental, moral, and spiritual, there was once a beginning, and that from a germ, by a gradual process of differentiation or specialization, the complex fabric of creation has, by the operation of natural laws and forces, been brought into being. All progress is dependent on this evolutionary principle, which involves variation, adaptation, the disuse or rejection of the unfit, the use or survival of the fittest, together with the mechanical principle of the utmost economy of material.

Though the human mind has its limitations and the chief arguments for evolution have been drawn from our observations of the history of our own planet and of the life existing upon it, the nebular hypothesis teaches us that the same process has determined the origin of other worlds than ours, and applies in fact to all the other members of our solar system, while with little doubt the principle may be extended to the entire universe.

At all events, evolutionary modes of thinking have now become a second nature with philosophic, synthetic minds, and to such any other view is inconceivable. We teach evolution in our colleges and universities, and the time is rapidly approaching, and in some instances has already come, when nature studies and the facts of biology forming the grounds of the

evolutionary idea will be taught in our primary and secondary schools.

The rapidity with which evolutionary conceptions have taken root and spread may be compared to the rankness of growth of a prepotent plant or animal on being introduced into a new territory where it is free from competition. It has indeed swept everything before it, occupying a field of thought which hitherto had been unworked by human intelligence.

The immediate effect, and a very happy one, of the acceptance of the theory of descent on working zoölogists is to broaden their minds. Collectors of insects and shells or of birds and mammals, instead of being content simply to acquire specimens for their cabinets, are led to look during their field excursions for examples of protective mimicry, or to notice facts bearing on the immediate cause of variation. Instead of a single pair of specimens, it is now realized that hundreds and even thousands collected from stations and habitats wide apart are none too many for the study of variation as now pursued.

The race of "species grinders" is diminishing, and the study of geographical distribution, based as it is on past geographical changes and extinctions, is now discussed in a far more philosophical way than in the past. The most special results of work in cytology and morphology are now affording material for broad work in phylogeny and heredity.

On the other hand, it must be confessed that, as the result of the acceptance of evolutionary views, our literature is at times flooded with more or less unsound hypotheses, some tedious verbiage and long-winded, aërial discussions, based rather on assumptions than on facts. But on the whole, perhaps, this is a healthy sign. Too free, exuberant growths will be in the long run lopped off by criticism.

One tendency should be avoided by younger students, that of too early specialization, and of empirical work without a broad survey of the whole field. In some cases our histologists and morphologists rise little above the intellectual level of species describers. Expert in the use of the microtome and of reagents, they appear to have but little more general scientific or literary culture than high-class mechanics. The chief anti-

dote, however, to the danger of narrowness is the lessons derived from evolutionary thought and principles.

Finally, as a proof of the value of evolutionary ideas to the present generation, let us suppose for a moment, if it were conceivable, that they should be blotted out. The result, it is safe to say, would be equivalent to the loss of a sense.

It is a matter of history that when a new idea or principle, or a new movement in philosophy or religion, arises, it at first develops along the line of least resistance; the leaders of the new thought acquire many followers or disciples. Soon the latter outstrip their teachers, and go to greater extremes; modifications of the original simple condition or theory occur, and as the final result there arise schisms and differentiations into new sects. This has happened in science, and already we have evolutionists divided into Lamarckians and Darwinians, with a further subdivision of them into Neolamarckians and Neodarwinians, while the latter are often denominated Weismannians. Some prefer to rely on the action of the primary factors of evolution, others believe that natural selection embraces all the necessary factors, while still others are thoroughly persuaded of its inadequacy.

The result of this analytical or differentiating process will probably be an ultimate synthesis, a belief that there is a complex of factors at work. Of these factors those originally indicated by Lamarck, with the supplementary ones of competition and natural selection bequeathed by Darwin, are the most essential and indispensable, and it is difficult to see how they can be displaced by other views. Meanwhile all agree, and it was never more firmly established than at this moment, that there is and always has been unceasing energy, movement, and variation, a wonderful adaptation and harmony in nature between living beings and their surroundings.

The present status of evolution in its different phases or attitudes since the time of the appearance of Darwin's *Origin of Species* may be roughly pointed out as follows: —

1. The claim by some thinkers of the inadequacy of Darwinism as such, or natural selection, to account for the rise of new species, and the assignment of this factor to what they

believe to be its proper place among the other factors of organic evolution.

2. The renascence of Lamarckism under the name of Neolamarckism, being Lamarckism in its modern form. This school relies on the primary factors of evolution, on changes in the environment, such as the agency of the air, light, heat, cold, changes in climate, use and disuse, isolation, and parasitism, while it regards natural, sexual, physiological, germinal, and organic selection, competition or its absence, and the inheritance of characters acquired during the lifetime of the individual, as secondary factors, calling into question the adequacy of natural selection as an initial factor.

3. The rise of the Neodarwinian school. While Darwin soon after the publication of the *Origin of Species* somewhat changed his views as to the adequacy of natural selection, and favored changes in the surroundings, food, etc., as causes of variation, his successors, Wallace, Weismann, and others, believe in the "all-sufficiency" of natural selection. Weismann also invokes panmixia, or the absence of natural selection, as an important factor; also amixia, and denies the principle of inheritance of acquired characters, or use-inheritance.

4. A third school or sect has arisen under the leadership of Weismann, who advocates what is in its essence apparently a revival of the exploded preformation, incasement, or "evolution" theory of Swammerdam, Bonnet, and Haller, as opposed to the epigenetic evolutionism of Harvey, Wolff, Baer, and the majority of modern embryologists. On the other hand, there are some embryologists who appear to accept the combined action of epigenesis and evolution in development.

5. Attention has been concentrated on the study of variations and of their cause. Opinion is divided as to whether variation is fortuitous, or definite and determined. Many now take exception to the view, originally held by Darwin, that variations are purposeless and fortuitous, believing that they are, for example, dependent on changes in the environment which were determined in early geological periods. For definite variation, Eimer proposes the term orthogenesis. Minute variations dependent on climatic and other obscure

and not readily appreciable causes are now brought out clearly by a system of varied and careful quantitative measurements.

6. More attention than formerly is given to the study of dynamical evolution, or kinetogenesis; to the effect of external stimuli, such as intermittent pressure, mechanical stresses and tensions by the muscles, etc., on hard parts. Originally suggested by Herbert Spencer, that the ultimate cause or mechanical genesis of the segmentation of the vertebrate skeleton was due to transverse strains, the segmentation of the bodies of worms and arthropods, as well as of vertebrates, has been discussed by recent workers (Ryder, Cope, Meyer, Tornier, Hirsch, and others). Here should be mentioned the work done in general physiology, or morphogenesis, by Verworm, Davenport, and others. Also the discoveries of Pasteur, and the application by Metschnikoff and of Kowalevsky of phagocytosis to the destruction and renewal of tissues during metamorphosis, bear closely on evolutional problems.

7. A new field of research founded by Semper, Vilmorin, and Plateau, and carried on by De Varigny, is that of experimental evolution, involving the effects of artificial changes of the medium, including temperature, food, variation in the volume of water and of air, absence of exercise, movement, etc. Also should be added horticultural experiments which have been practised for many years, as well as the results of acclimatization.

Here should be mentioned the experiments bearing on the mechanics of development (Entwickelungsmechanik der Organismen), or experimental embryology, of Oscar Hertwig, Roux, Driesch, Morgan, and others, and the curious results of animal grafting and of mutilations of the embryos, obtained by Born and others, as well as the regeneration of parts. The remarkable facts of adaptation to new and unfavorable conditions of certain embryos are as yet unexplained, and have led to considerable discussion and research.

8. The *a priori* speculations of Darwin, Galton, Spencer, Jaeger, Nusbaum, Weismann, and others, based on the results of the labors of morphologists and cytologists, have laid the foundation for a theory of the physical basis of heredity, and

for the supposition that the chromatin in the nucleus of reproductive cells is the bearer of heredity. The theory has already led to prolonged discussions and opened up new lines of work in cytology and embryology.

9. The subject of instinct, discussed both by morphologists and psychologists, particularly by Lloyd Morgan, has come to the front, while mental evolution has been discussed by Romanes and others.

With all these theories before us, these currents and counter currents in evolutional thought bearing us rapidly along, at times perhaps carrying us somewhat out of our depth, the conclusion of the whole matter is that in the present state of zoölogy it will be wise to suspend our judgment on many theoretical matters, to wait for more light, and to confine our attention meanwhile to the observation and registration of facts, to careful experiments, and to repeated tests of mere theoretical assumptions.

Meanwhile we may congratulate ourselves that we have been born and permitted to labor in this nineteenth century, the century which in zoölogical science has given us the best years of Lamarck's life, a Cuvier, a Darwin, a von Baer, an Owen, an Agassiz, a Haeckel, a Spencer, and a Huxley — the founders of modern zoölogy — who have sketched out the grander features of our science so completely that it will, perhaps, be the work of many coming years to fill in the details.

Geological Causes of Variation and of the Extinction and Renewal of Species.

The most immediate and efficient cause of variation appears to be changes of environment or of the physical conditions of existence. These, besides the agencies of gravity, electricity, of the atmosphere, light, heat, cold, food, etc., comprise geological changes or revolutions in the topography of the earth's surface at different periods. The latter causes appear to have had much to do with the process of extinction and renewal of plants and animals.

While the doctrine of the effect on animals of a change of environment was suggested very early in this century and forms the corner stone of Lamarckism, Wallace was, after De la Beche[1] and especially Lyell,[2] the first in recent times, in an essay published in 1855, to call attention to this subject thus:

"To discover," he says, "how the extinct species have from time to time been replaced by new ones down to the very latest geological period, is the most difficult, and at the same time the most interesting problem in the natural history of the earth."[3]

Still more recently[4] he remarks:

"Whenever the physical or organic conditions change, to however small an extent, some corresponding change will be produced in the flora and fauna, since, considering the severe struggle for existence and the complex relations of the various organisms, it is hardly possible that the change should not be beneficial to some species and hurtful to others."

Two conclusions are now generally accepted: the first is, that the most complete evidence of evolution is afforded by paleontology. Huxley's vigorous affirmation that the primary and direct evidence in favor of evolution can be furnished only by paleontology has been greatly strengthened by recent discoveries. The second is, that biological evolution has been primarily dependent on physical and geological changes.

It may not be unprofitable for us as zoölogists to pass in review some of the revolutions in geological history, particularly as regards our own continent, some important details of which have recently been worked out by geologists, and to note the intimate relation between these revolutions and the origination not only of new species but of new faunæ, and indeed, at certain epochs, of new types of organic life.

1. *Precambrian Revolutions.* — That immensely long period which intervened between the time when our planet had cooled down and become fitted for the existence of animal life, and the opening of the Cambrian period, was evidently a time of the geologically rapid production of ordinal and class types of

[1] *Researches in Theoretical Geology*, p. 217. New York, 1837. Quoted by Woodworth, p. 220.

[2] *Principles of Geology*. 1839.

[3] *Natural Selection*, p. 14.

[4] *Darwinism*, p. 115. 1889.

invertebrate life. This is strongly suggested by the fact that a large proportion of the Cambrian classes embrace forms as highly specialized as their successors of the present day, so that we are compelled to look many ages back of the Cambrian for the appearance of their generalized ancestral forms.

Of the eight branches of phyla, of the animal kingdom, the remains of seven, or all except the vertebrates, have been found in Cambrian strata. Adopting the kind of statistics employed by Prof. H. S. Williams in his admirable *Geological Biology*, but with some changes necessitated by a little different view as to the number of classes living at the beginning of the Cambrian period, it appears that 13 out of 26 classes of the animal kingdom, occurring in a fossil condition, already existed in the Cambrian, and, if we throw out from the vertebrate classes those without a solid skeleton (the Enteropneusta or Balanoglossus, Tunicates, Amphioxus, and the lampreys), 13 out of 22. Also, if we exclude the land forms (Arachnida, Myriopoda, and insects), 13 out of 19; and then, throwing out the five vertebrate classes found in a fossil state, of 14 invertebrate marine classes 13 occur in the Cambrian.[1] With little doubt, flatworms, nemerteans, Nematelminthes, and Gephyrea existed then, and probably the representatives of other classes of which no traces will ever occur.

We shall for our present purpose follow the classification of the United States Geological Survey and restrict what was formerly called the Archæan to the fundamental gneiss and crystalline schists of an unknown thickness, and accept the Algonkian, as comprising the Huronian and Keweenawan formations. We may assume that the first beginnings of life took place toward the end of the Archæan, and that the more or less rapid differentiation of class types went on during Algonkian time. This view is fortified by the statement of Walcott that a great orographic movement, followed by long-continued erosion, took place between the Archæan and Algonkian ages.

[1] Should the Polyzoa be traced back to the Cambrian, as it is not at all impossible, the fact would remain that every class of marine invertebrates with solid parts is represented in the Cambrian.

Taking as an example of the nature of the Algonkian changes one region alone, the Lake Superior region, where the stratigraphical record is more complete, we have: —

1. The Lower Huronian schists, limestone, quartzites, conglomerates, etc., with their eruptives, closely folded and attaining a maximum thickness of probably over 5000 feet.

2. The Upper Huronian, unconformable to the Lower, a series of more gently folded schists, slates, quartzites, conglomerates, interbedded and cut by trap, with a maximum thickness of 12,000 feet. In the Animikie quartzites of this age have, according to Selwyn, been detected a track of organic origin, and in the Minnesota quartzites, Lingula-like forms, as well as obscure "trilobitic-looking" impressions; while carbonaceous shales are abundant.

3. Between these Huronian rocks and the true Cambrian series are interpolated the Keweenawan elastic rocks, with a maximum thickness of 50,000 feet. Though these beds are by some high authorities referred to the Cambrian, the fact remains that this series, whether Cambrian or Algonkian, is unconformable to the Huronian, and composed of fragmental rocks, the upper division being 15,000 feet thick, and consisting wholly of detrital material largely derived from the volcanoes of the same series. Between each series is an unconformity representing an interval of time long enough for the land to have been raised above the seas, for the rocks to have been folded and to have lost by erosion thousands of feet, and for the land to have sunk below the surface of the ocean.

Again, between the Precambrian and Cambrian there was, according to Walcott, a great uplift and folding of rock, succeeded by long-sustained erosion, over all the continental area. It was not, however, he states, "as profound as the one preceding Algonkian time, as is proved by the more highly contorted and disturbed Archæan rocks beneath the relatively less disturbed Algonkian series." [1]

The evidence of the existence of life forms in the Huronian and Keweenawan times is indicated by the presence of thick

[1] The North American Continent during Cambrian Time. *Twelfth Ann. Rep. U. S. Geological Survey*, p. 544.

beds of graphitic limestone, beds of iron carbonates, and by a great thickness of carbonaceous shales, which are represented by graphitic schists in the more altered strata. In the Animikie rocks on the northern shores of Lake Superior Ingall finds abundant carbon, and it is said that in certain mines and openings rock gas forms to a considerable extent. Also small quantities of rock may even be obtained which will burn. "These substances must result from the ordinary processes which produce rock gas and coal in the rocks of far later age. The hydrocarbons which occur so abundantly in the slightly metamorphosed shales of the Huronian about Lake Superior must be of organic origin," and if so, the graphitic schists of the same system "are in all probability only these hydrocarbonaceous shales in a more altered condition."

As to the fossils actually detected in what are by some geologists regarded as Algonkian strata, Winchell has detected a Lingula-like shell in the pipestones of Minnesota. Selwyn has described tracks of animals in the Upper Huronian of Lake Superior. Murray, Howley, and Walcott have discovered several low types in the Huronian of Newfoundland, *i.e.*, a mollusk (*Aspidella terranovica*)[1] and traces of a worm (*Arenicolites spiralis*), the latter said to occur in the primordial rocks of Sweden. Walcott reports the discovery in the Grand Cañon of the Colorado of the following Precambrian fossils: "A minute discinoid or patelloid shell, a small Lingula-like shell, a species of Hyolithus, and a fragment of what appears to have been the pleural lobe of the segment of a trilobite belonging to a genus allied to the genus Olenellus, Olenoides, or Paradoxides. There is also an obscure Stromatopora-like form that may not be organic."

Here should be noted the discovery, in 1896, of Radiolaria[2]

[1] Dr. G. F. Matthew writes me as follows regarding this supposed fossil: "I have seen *Aspidella terranovica* in the museum at Ottawa and doubt its organic origin. It seems to me a slickensided mud-concretion striated by pressure. I have found similar objects in the Etcheminian olive-gray beds below the St. John group."

[2] Dr. Matthew likewise writes me: "The (Radiolarian ?) rocks of Adelaide, South Australia, Mr. Howchin writes to me he now finds to be Lower Cambrian. He has found Archæocyathus in them; but this is not proof of *Lowest* Cambrian, as the genus is found in the Paradoxides beds of the South of France."

in calcareous and cherty rocks of "undoubted Precambrian age" near Adelaide, Australia (*Nature*, Dec. 24, 1896, p. 192); the detection of fossils in the Archæan of Brittany, and of three veins of anthracite "in crystalline schists of Archæan age" in Ecuador.

At St. John, New Brunswick, that able and experienced geologist, Dr. G. F. Matthew, has detected fossils in strata which he refers to the Upper Laurentian. They occur in three horizons. The lowest series is composed of a quartzite containing fragments of the skeletons of hexactinellid sponges allied to Cyathospongia. In the upper limestone of the second horizon were collected calcareous coral-like structures resembling *Stromatopora rugosa*. In the third and uppermost horizon, consisting of beds of graphite, occurred great numbers of spicules of apparently hexactinellid sponges. "Between this upper Laurentian system and the basal Cambrian occurs," says Matthew, "a third system, the Coldbrook and Coastal, Huronian, which has given conglomerates to the Cambrian and has a great thickness." He also tells us that the Precambrian St. Etcheminian beds at St. John, consisting of red and green slates and shales, have a meager fauna, comprising Protozoa, Brachiopoda, echinoderms, mollusks, with plentiful worm burrows and trails. In commenting on this subject Sir J. W. Dawson remarks that these Etcheminian strata rest on Huronian rocks which, near Hastings, Ontario, contain worm burrows, sponge spicules, "and laminated forms comparable to Cryptozoön and Eozoön." (*Nature*, Oct. 15, 1896, p. 585.)

Even allowing room for error in the correlation of these formations, and in regarding some of these rocks as no older than Cambrian, yet on the whole the result appears to be that abundant vegetation existed in Precambrian times, which was converted into graphite, while representatives of seven classes were perhaps already in existence previous to the Cambrian period.

The following lists give a comparative view of the classes of the periods in question:

Precambrian Classes.	*Cambrian Classes.*
Rhizopoda (Radiolaria).	Rhizopoda (Foraminifera and Radiolaria).
Porifera (Hexactinellid Sponges).	Porifera (Sponges).
	Hydrozoa (Medusæ and Graptolites).
Actinozoa (Corals).	Actinozoa (Corals).
Brachiopoda.	Brachiopoda.
Annelida.	Annelida.
	Crinoidea.
	Asteroidea.
	Lamellibranchiata.
Mollusca.	Gastropoda (including Pteropoda).[1]
	? Cephalopoda (Orthoceras ?).
Trilobita.	Trilobita.
	Crustacea.

It would seem from these data that the physical condition of the sea and atmosphere was favorable to the existence of types for aught we know quite or nearly as highly specialized as those of the same classes now in existence. Life and nature in the Precambrian went on, so far as we can tell, much as in Cambrian times. Though locally there are breaks in the continuity of geological processes, yet probably over the world generally there was a continuity of geological phenomena, and on the whole a tolerably unbroken series of organic forms.

It is obvious, however, that in the regions thus far examined, the Precambrian, whether we include the Archæan or not, more than at any time since, though the land areas are by some considered to be of small extent, was a period of widespread and profound changes in the distribution of land and sea. While it is generally supposed that the extent of the continental areas at the beginning of Paleozoic time was small, forming islands, Walcott is inclined to the belief that it was very considerable, stating:

The continent was larger at the beginning of the Cambrian period than during any epoch of Paleozoic time, and probably not until the development of the great fresh-water lakes of the Lower Mesozoic was there such a broad

[1] Dr. Matthew writes me that he doubts if Hyalithoid shells should be referred to Pteropoda. "Pelsineer quite repudiates them; and to me their heavy shells, and frequent habitat on rough shores, do not speak of the fragile Pteropoda."

expanse of land upon the continental platform between the Atlantic and Pacific oceans. The agencies of erosion were wearing away the surface of this Algonkian continent and its outlying mountain barriers to the eastward and westward, when the epoch of the Lower Cambrian or Olenellus zone began. The continent was not then new. On the contrary, it was approaching the base level of erosion over large portions of its surface. The present Appalachian system of mountains was outlined by a high and broad range, or system of ranges, that extended from the present site of Alabama to Canada, and subparallel ranges formed the margins of basins and straits to the east and northeast of the northern Paleo-Appalachian or the Paleo-Green Mountains, and their northern extension toward the Precambrian shore line of Labrador. The Paleo-Adirondacks joined the main portion of the continent, and the strait between them and the Paleo-Green Mountains opened to the north into the Paleo-St. Lawrence Gulf, and to the south extended far along the western side of the mountains and the eastern margin of the continental mass to the sea that carried the fauna of the Olenellus epoch around to the Paleo-Rocky Mountain trough. (*Loc. cit.*, p. 562.)

Remarking on the habitat, or nature and extent of the sea bottom tenanted by the Olenellus or Lower Cambrian fauna, Walcott remarks:

One of the most important conclusions is that the fauna lived on the eastern and western shores of a continent that, in its general configuration, rudely outlines the North American continent of to-day. Strictly speaking, the fauna did not live upon the outer shore facing the ocean, but on the shores of interior seas, straits, or lagoons that occupied the intervals between the several ridges that rose from the continental platform east and west of the main continental land surface of the time. (*Loc. cit.*, p. 556.)

Dana had previously (1890) claimed that the earth's features, even to many minor details, were defined in Archæan time (evidently referring to all Precambrian time), and that "Archæan conditions exercised a special and even detailed control over future continental growth." May not this idea be extended to include the life of the Precambrian, and may we not suppose that biological variations and evolutions were predetermined, to some degree at least, by the geological conditions of these primeval ages? The continental masses were then foreshadowed by submarine plateaus covered by shallow seas, the deeper portions of the ocean basins not being affected by these oscillations, extensive as they were.

The time which elapsed between the end of the Laurentian and beginning of the Cambrian was immense, or, at least, as long as the entire Paleozoic era. Walcott estimates the length of the Algonkian at 17,500,000 years. This length of time, or even a portion of it, was long enough for the origination and establishment of those classes, whose highly specialized descendants flourished in the Cambrian. Referring to the Precambrian strata Walcott states :

> That the life in the pre-Olenellus seas was large and varied there can be little if any doubt. The few traces known of it prove little of its character, but they prove that life existed in a period far preceding Lower Cambrian time, and they foster the hope that it is only a question of search and favorable conditions to discover it.[1]

Here the imagination of the zoölogist may be allowed for the moment free scope to act. It is perhaps not hazardous to surmise that in the early centuries or millenniums of the Huronian there arose from some aggregated or compound infusorian, the prototype of the sponges.

From some primitive gastrula, which became fixed to the Huronian sea bottom, may have arisen the hydroid ancestor of the Cœlenterates ; owing to its fixed mode of life, the primitive digestive cavity opened upwards, being held in place by the septa, so that the vase-shaped body, growing like a plant, with the light striking upon it from all sides, assumed a radial symmetry. Before the beginning of the Cambrian, for we know Aurelia-like forms abounded on the Cambrian coasts, medusæ budded out from some hydroid polyps, became free swimming, and as a result of their living at the surface became transparent, and thus shielded from the observation of whatever enemies they had, multiplied in great numbers.

From some reptant gastræa there may have sprung, in these primeval times, an initial form with a fore-and-aft, dorso-ventral and bilateral symmetry, which gave origin by divergent lines of specialization to flatworms, nemerteans, and roundworms, as well as Rotifera, and other forms included among the Vermes. It is probable that the trematodes and cestodes, especially the

[1] The Fauna of the Lower Cambrian or Olenellus Zone. *Tenth Ann. Rep. U. S. Geological Survey*, 1888, 1889.

latter, whose organs have undergone such reduction by parasitism, and some of which through disuse have totally disappeared, did not evolve until some time after the appearance of mollusks and fishes.

When existence in these early plastic vermian forms was confined to boring in the mud and silt, the body became cylindrical, as in some nemerteans, and in the threadworms ; some of the latter forms, boring into the mud, became parasites, entering the bodies of other animals which serve as their hosts.

At about this time certain worms, as the simple mechanical result perhaps of threading their way over or through the rough gravelly bottom, became segmented. The establishment of a segmented structure, brought about by the serpentine mode of progression in the direction of least resistance, resulted in the origination of a succession of levers. Following this annulated division of the dermo-muscular tube of worms was the serial or segmental arrangement of the internal organs, *i.e.*, the nervous, excretory, reproductive and glandular, and, in a less degree, the circulatory system.

In certain of these primitive protannelids, as the result perhaps of external stimuli intermittently applied, bristles originated to aid in progression, and finally the segmentally arranged lateral flaps of the skin, the parapodia, which served as swimming organs. Other nepionic forms, at first free swimming, became fixed and protected by two valves, as in the Brachiopoda, which owe their success in Precambrian times to their fixed and protected bodies.

Not long after the annelid type became established, that of the echinoderms apparently diverged from some nepionic worm, like a trochosphere. In such a form there was a tendency to the deposition of particles and plates of lime in the walls of the body, and the type becoming fixed at the bottom, or at least nearly stationary, and meanwhile more or less protected by a calcareous armor, lost its originally bilateral, and acquired a radial symmetry.

But no echinoderms have yet been detected in Precambrian rocks, which, however, have revealed arthropods, as shown by

the traces of a trilobite, and this tends to indicate that radial symmetry is an acquired, not a primitive characteristic.

At this time was solved the problem of the origination of a type of body, and of supports for it either in walking or in swimming, which should fulfill the most varied conditions of life, and this type, the arthropodan, as events proved, was that fitted for walking over the sea bottom, for swimming, or for terrestrial locomotion ; nor was the idea of segmentation both in trunk and limbs discarded when the type culminated in flying forms, — the insects.

The Arthropoda, as the record shows, first represented by trilobites, which structurally are nearer the annelids than Crustacea, was destined to far outnumber in individuals, species, orders, and classes, any other phylum. Fundamentally worm-like or annelid in structure, the body consisted of a linear series of stiff levers, and was supported by limbs segmented in the same way. The variations of the arthropodan theme are greater than in any other groups, and nature, so to speak, succeeded most admirably in this type, with the exception of the Trilobita, which was the first class of the phylum to appear and the first to disappear. The evolution of jointed limbs was accomplished in the most economical and direct way. The parapodia were perhaps utilized, and at first retaining their form in swimming phyllopods, afterwards from being used as supports, became cylindrical and jointed. All this modification of monotypic forms and evolution from them to other types was accomplished not very late perhaps in the Precambrian. After the specialization of the antennæ and of the trunk segments of the trilobites was worked out, all the postantennal appendages being alike, there ensued in some descendant of another vermian ancestor a further differentiation of the postantennal appendages into mandibles, maxillæ, maxillipedes, thoracic ambulatory legs, and abdominal swimming feet, as worked out in the more specialized members of the class of Crustacea.

As soon as the crustacean type became established, the conditions must have been most favorable for its rapid differentiation along quite divergent lines, for in the Cambrian strata occur the remains of four orders, *viz.*, the Cirrhipedia, Ostra-

coda, Phyllopoda, the sole Cambrian form (*Protocaris marshi*) related to the modern Apus, and the Phyllocarida. Of these the barnacles and ostracodes with their multivalve or bivalve carapaces are the most specialized, and in the case of the former the process of modification due to this fixed mode of life must have required ages, as must also the development of that highly modified vermian type, the Brachiopoda.

Indeed, the three lines of descent which resulted in the arthropodan phylum, as it now exists, unless there were three independent phyla, were perhaps initiated before the Cambrian. These lines are: (1) the Trilobita, with their probable successors the merostomes and arachnids; (2) the Crustacea; and (3) the myriopods and insects. Of the third line Peripatus or a Peripatus-like form was the earliest ancestor, which of course must have been terrestrial in habits, though its forefather may have been some fresh-water leech-like worm. We venture to state that it is not wholly impossible that so composite a type as Peripatus, which bears at least some of the marks of being a persistent type, took its rise on the continental land of the Precambrian.

In the Precambrian time was also solved the problem by the mollusks of producing a spiral univalve shell; for while a large proportion of the Gastropoda were protected by patella-like shells of simple primitive conical form, with these coexisted, in the Lowest Cambrian, forms with spiral shells, such as Platyceras and Pleurotomaria. The comparative abundance of those highly modified mollusks, the Pteropoda, in the lowest or Olenellus Cambrian strata, strongly suggests that their divergence from the more generalized gastropod stem, and their adaptation to a surface or pelagic life, must have taken place long anterior to the dawn of the Cambrian.[1] With them must have lived a variety of other surface forms besides Rhizopoda, whose young served as their food. The members of all classes of the Cambrian were carnivorous, feeding on the protoplasm of

[1] Dr. Matthew has discovered at St. John, N. B., a still lower and older bed, containing no Olenellus, but Foraminifera (Orbulina and Globigerina), sponges, Pteropoda, Pelagiella, which was probably an oceanic heteropod, very primitive brachiopods, with Ostracoda and six genera of trilobites.

the bodies of microscopic animals, or on the eggs and young of their own species, some living on the bottom, and others at the surface. Of marine plants of the Cambrian there are but slight traces, and it is evident that what there were were restricted to the coasts and to shallow water. The old idea that plants originally served as the basis of animal life must be discarded. As at present no plant life exists below a few fathoms, a hundred perhaps at the most, and since below these limits the ocean depths are packed with animal life which exists entirely on the young or the adults of weaker forms, so must the rise and progress of animal life have been quite independent of that of plants. The lowest plants and animals may have evolved from some common bit of protoplasm, some protist, but the evolution of the animal types became very soon vastly more complex. The specialization of parts and adaptation to the environment were more thorough and rapid in the lowest animals evidently in consequence of the greater power of locomotion, and aggressiveness in obtaining food from living organisms, and the adaptability of animal life to various oceanic conditions, especially temperature, bathymetrical conditions and a varying sea bottom.

This rapid differentiation and multiplication of different family, ordinal, and class ancestral types went on without those biological checks which operated in later times, when the seas and land masses of the globe became more crowded. There was a comparative absence of competition and selection ; this being due to the lack of predaceous carnivorous forms to produce that balance in nature which afterwards existed. The two most successful and abundant types were the trilobites and brachiopods ; but the former were not especially aggressive in their habits, undoubtedly taking their food in a haphazard way by burrowing in the mud or sand, having much the same kind of appendages and the same feeding habits as Limulus. The brachiopods were fixed or burrowed in the sand, straining the microscopic organisms drawn into the mouth by the currents set up through the action of their ciliated arms. The most destructive and aggressive Cambrian animals known to us were the orthoceratites, but their remains have not yet been

detected below the second Cambrian zone. Even if some protocordate Balanoglossus, ascidians, or even Amphioxus had already begun their existence in these Precambrian times, they could have caused but a little more destruction of life than their contemporaneous invertebrate allies. As the remains of Ostracodermi and sharks have been detected in Trenton strata, perhaps they originated in the Cambrian, when they must have been active forces in the elimination of those Precambrian soft-bodied animals which connected classes now quite wide apart.

The rapid increase in the Precambrian population was hastened by the probable fact that this, more than any subsequent period, was one of rapid migration and colonization. Vast areas of the shallow depths over the site of the embryo continent, more or less shut off from the main ocean by shoals, reefs, and islands, were, by oscillations of the sea bottom and land, opened up at various times to migrants from the older previously settled seas.

The nature of the Precambrian sediments shows that the more open sea bottom was swept by tidal and ocean currents varying in strength and extent. The topography of the ocean bottom over what is now land must have been more diversified than at present. In the late ages of the Algonkian, owing to active competition and the struggle for existence in the overstocked areas, the process of segregation or geographical isolation was rapidly effected, and the migrants from the denser centers of growth pressed into the then uninhabited areas where, as new, vigorous, and prepotent colonists, they broke ground and founded new dynasties.

At such times as these we can easily imagine that, besides the absence of competition, the Lamarckian factors of change of surroundings bringing about new habits and thus inducing new needs, the use and disuse of organs, together with the inheritance of characters acquired during the lifetime of the individual, operated then far more rapidly and in a much more thoroughgoing way than at any period since, while all through this critical, creative period, as soon as there was a sufficient diversity in the incipient forms and structures, a selective principle began to operate.

For forty years past, since the time of Darwin, the idea that these early forms were more rapidly evolved, and that they were more plastic than forms now existing, has constantly cropped out in the writings of our more thoughtful and studious paleontologists and biologists.

Darwin, in his *Origin of Species*, as quoted by Walcott with approval, remarked that it is indisputable that, before the Lowest Cambrian stratum was deposited, long periods elapsed, as long as, or probably far longer than, the whole interval from the Cambrian age to the present day; and that "during these vast periods the world swarmed with living creatures." Darwin then adds: "It is, however, probable, as Sir William Thompson insists, that the world at a very early period was subjected to more rapid and violent changes in its physical conditions than those now occurring; and such changes would have tended to induce changes at a corresponding rate in the organism which then existed."

Professor Hyatt,[1] from his exhaustive studies on the Nautiloidea and Ammonoidea, concludes:

> These groups originated suddenly and spread out with great rapidity, and in some cases, as in the Arietidæ of the Lower Lias, are traceable to an origin in one well-defined species, which occurs in close proximity to the whole group in the lowest bed of the same formation. These facts, and the acknowledged sudden appearance of large numbers of all the distinct types of invertebrates in the Paleozoic, and of all the greater number of all existing and fossil types before the expiration of Paleozoic time, speak strongly for the quicker evolution of forms in the Paleozoic, and indicate a general law of evolution. This, we think, can be formulated as follows: *Types are evolved more quickly and exhibit greater structural differences between genetic groups of the same stock while still near the point of origin, than they do subsequently. The variations or differences may take place quickly in the fundamental structural characteristics, and even the embryo may become different when in the earliest period, but subsequently only more superficial structures become subject to great variations.*[2]

If this applies to the evolution of these cephalopods in the Mesozoic, how much more rapidly and efficaciously did the principle operate in the Precambrian period, after the initial

[1] Phylogeny of an Acquired Characteristic. *Proc. Amer. Phil. Soc.*, vol. xxxii, p. 371.

[2] *Geological Biology*, p. 322.

steps in the divergence of types from the unicellular Protozoa took place? The same law of fact obtains with the insects, the eight holometabolous orders having, so far as the evidence goes, originated at nearly the same geological date, near or soon after the close of the Paleozoic era. Williams also shows from a study of the variations of *Atrypa reticularis* that this species in its specific characters shows a greater degree of variability of plasticity in the earlier than in the later stages of its history. We thus conclude that after the simplest protoplasmic organisms originated, the greatest difficulties in organic development, *i.e.*, the origination of the founders of the different classes, were, so to speak, met and overcome in Precambrian times. The period was one of the rapid evolution of types. As Williams[1] has well remarked:

> The chief expansion of any type of organism takes place at a relatively early period in its life-history. Since then, as with the evolution of the continent itself, the farther progressive differentiation of marine invertebrate forms has, since the close of the Precambrian, been a matter of detail.

As well stated by Brooks, since the first establishment of the Cambrian bottom fauna, "evolution has resulted in the elaboration and divergent specialization of the types of structure which were already established, rather than in the production of new types."

In accepting the general truth of this statement and its application to the marine or Cambrian types, it may, however, be modified to some extent. For during the late Paleozoic was witnessed the evolution of the three tracheate, land-inhabiting, air-breathing classes of Arachnida, Myriopoda, and insects, and of the air-breathing vertebrates, with limbs and lungs, comprising the four classes of amphibians, reptiles, birds, and mammals.

2. *The Appalachian Revolution and its Biological Results.*— Unless we except the great changes in physical geography which took place at the end of the Tertiary period, when the mountain chains of each continent assumed the proportions we now see, the Appalachian revolution, or the mountain building and continent making at the close of the Paleozoic age, was

[1] *Loc. cit.*, p. 347.

the most extensive and biologically notable event in geological history. In its effects on life, whether indirect or direct, it was of vastly greater significance than any period since, for contemporaneous with, and as a consequence of, this revolution was the incoming of the new types of higher or terrestrial vertebrates. Through the researches, now so familiar, in the field and study, of the two Rogerses, of Dana, and of Hall, we know that all through the Paleozoic era at least some 30,000 to 40,000 feet of shoal water sediments, both marine and fresh water, derived from the erosion of neighboring lands, were accumulated in a geosynclinal trough over the present site of the range extending from near the mouth of the St. Lawrence to northern Georgia. At the end of the era ensued a series of movements of the earth's crust resulting from the weight of this vast accumulation, which in a geologically brief period sank in, dislocated, and crushed the sides of the trough, and folded the strata into great close parallel folds, besides inducing more or less metamorphism. These folds rising from a plateau formed mountain ranges perhaps as high as the Sierra Nevada or Andean Cordillera of the present day. The plateau emerged above the surface of the Paleozoic ocean, and was carved and eroded into mountain peaks, separated by valleys of erosion, the rivers of the Appalachian drainage system cutting their channels across the mountain ranges.

But this process of mountain building and erosion was not confined to the end of the Paleozoic era. Willis [1] has shown that there have been several successive cycles of denudation, covering a period extending from the end of the Paleozoic era to the present time. And it is the fact of these successive cycles of denudation both on the Atlantic and Pacific slopes of our continent that is of high significance to the zoölogist from the obvious bearings of these revolutions on the production of variations. Indeed it is these phenomena which have suggested the subject of this address.

We can imagine that this great plateau, in the beginning of the Mesozoic era, with its lofty mountain ranges and peaks rising from the shores of the Atlantic, presented different

[1] *National Geographical Magazine*, vol. i (1889), pp. 291–300.

climatic zones, from tropical lowlands with their vast swamps, to temperate uplands, stretching up perhaps to Alpine summits, with possibly glaciers of limited extent filling the upper parts of the mountain valleys. New Zealand at the present day has a subtropical belt of tree ferns, while the mountains bear glaciers on their summits; and in Mexico, only about 20° from the tropics, rising above the tropical belt, is the temperate plateau, and farther up the subalpine snow-clad summits of Popocatepetl, Orizaba, and other lofty peaks. So in the Appalachians of the Paleozoic, the cryptogamous forests and their animal life may have been confined to the coastal plains and lowlands, while on the higher, cooler levels may have existed a different assemblage of life; and it is not beyond the reach of possibility that a scanty subalpine flora peopled the cooler summits.

But the unceasing process of atmospheric erosion and river action continued through the Jurassic, which was, as stated by Scott in his *Introduction to Geology*, "a time of great denudation, when the high ranges of the Appalachian Mountains were much wasted away, and the newly upheaved, tilted, and faulted beds of the Trias were deeply eroded." At about the time of the opening of the Cretaceous the range was reduced to a peneplain (the Cretaceous peneplain), with only vestiges of once lofty mountains, the scenic features roughly recalling those of North Carolina and New England at present, although more subdued and featureless, more like the Kittatinny peneplain of the Piedmont district at the eastern base of the Blue Ridge to-day as contrasted with the present mountain region of Pennsylvania and New Jersey. There were also extensive changes in the interior. What was the Colorado island was added to the mainland, and a great Mediterranean sea extended from the Uinta Mountains of southeastern Wyoming to New Mexico and Arizona, and stretched from the Colorado peninsula westward to Utah. In the Upper Jurassic as the result of a depression a gulf was formed over northern Utah, Wyoming, and southern Montana (Scott).

The formation of this Cretaceous peneplain was succeeded by a reëlevation, and the surface which is now Virginia was

gradually raised to a height of 1400 feet, and again the sluggish rivers of the Cretaceous times were revivified, cutting through the harder strata forming the walls of the longitudinal valleys, and, widening into broad estuaries, emptied into the Atlantic.

In the Eocene Tertiary, as Willis tells us, "the swelling of the Appalachian dome began again. It rose 200 feet in New Jersey, 600 feet in Pennsylvania, 1700 feet in southern Virginia, and thence southward sloped to the Gulf of Mexico." In consequence of the renewed elevation, the streams were revived; and Willis adds: "Once more falling swiftly they have sawed and are sawing, their channels down, and are preparing for the development of a future base-level." [1]

We can in imagination see, as the result of these widespread physical changes, inducing as they must have done the formation of separate basins or areas enclosed by mountain ranges, with different climates and zones on land, however uniform might have been the general temperature of the world at that time and the other physical conditions of the sea, — we can imagine the profound and deep-seated influence thus exerted on the life-forms peopling the uneven surface of the land.

The vegetation of the lowlands was rich and luxuriant, as the Triassic (Newark) coal deposits near Richmond testify, and while the uplands and hills were probably clad with dense forests of conifers, on the drier desert areas of the peneplain the trees may have been more scanty, like the scattered pines of the drier elevated region of the southwest, and of the Great Basin at the present day. The distribution of the animal life must have corresponded; one assemblage, especially the amphibians, characterizing the hot and humid lowlands, another the cooler uplands, while already perhaps a few forms became adapted to the more arid desert areas, as is the case now in Australia, which is in a sense a Mesozoic continent.

Similar subsidences and elevations changed the Jurassic map in Eurasia. This continent was already a land mass of great extent, and fresh-water lakes extended across Siberia, and in China were extensive swamps and submerged lands, now repre-

[1] Quoted from Scott's *Introduction to Geology*, p. 342.

sented by coal fields. Afterwards in the Middle Jura this continent subsided, and the Jurassic sea covered the greater part of Europe and Asia, this being, according to Neumayr, "one of the greatest transgressions of the sea in all recorded geological history." Subsidences and elevations resulted, it is supposed, in cutting off India from Eurasia so that the strait or sea covered the site of the Himalayas, and India was possibly joined to Australia, the Malaysian peninsula forming the connecting link; or perhaps it stretched to the southwestward and was joined to South Africa. However this may be, it is sufficient for our present purpose that these vast changes in the relative position of land and sea were productive of a corresponding amount of variation, and perhaps of immigration and consequent isolation. At all events, throughout the Jurassic seas as a whole there seemed to have been remarkable faunal differences. This led Neumayr, in which he is followed by Kayser,[1] to conceive that there were already in Jurassic times climatic zones, corresponding to the boreal, polar, north and south temperate, and tropical zones of the present day. If, however, with Scott, we reject this view, and substitute for it the supposition that "the marked faunal differences are due to varying facies, depth of water, character of bottom, etc., and even more to the partly isolated sea basins and the changing connections which were established between them," it is of nearly the same import to the geological biologist, for these varying conditions of the Jurassic ocean bottom could not have been without their influence in causing variation, modification, and adaptation to this or that set of conditions of existence.

Turning now to the effects of the Appalachian revolution on the life of that time, we see that the biological results were, in the main, in conformity with the geological changes. During the Carboniferous period vertebrates with limbs and lungs appeared, *i.e.*, the labyrinthodonts or Stegocephala. They were, compared with the other orders of their class, the most composite and highly organized of the Amphibia.

Throughout the long period of comparative geological quiet,

[1] *Text-Book of Comparative Geology*, translated and edited by Philip Lake, pp. 270, 271.

those long ages of preparation which ended in the crisis or cataclysm which closed the Paleozoic, the amphibian type was slowly being evolved in the swamps and bayous of the lowlands of the Devonian, whose vegetation so nearly anticipated that of the Carboniferous, from some Devonian [1] or late Silurian ganoids, from which diverged on the one hand Dipterus and the colossal lungfish (Dinichthys and Titanichthys) of the Devonian, and perhaps on the other the labyrinthodonts, which may have sprung from some crossopterygian fish like Polypterus, and whose pectoral and ventral fins became adapted for terrestrial locomotion. The type evidently was brought into being, provoked by, and at the same time favored by, the great extent of low coastal swampy land and bodies of fresh water which bordered the Atlantic seaboard from the Silurian time on.

How the amphibian type arose from the ganoid stock is a matter of conjecture. It may, however, be surmised that certain of the lungfishes or forms like them, adapted for breathing the air direct when out of the water in the dry season, instead of remaining in their mud cells waiting for the rains to fill the lakes or swell the rivers, attempted, like the Anabas, or climbing fish, to migrate in schools overland; or, like that fish which is said to have become "so thoroughly a land animal that it is drowned if immersed in water," [2] it may have become confined to the land, and, losing its gills, used its lungs only. As the final result of its efforts to walk over the damp soil and mud of swampy regions, the uniaxial fins may have developed, through the strains and pressures of supporting the clumsy body, into props with several leverage systems; the basalia instead of remaining in one place, as in a fish's fin, spreading out and becoming digits to support the weight and steady the body while walking. This process was not confined to one or to a few individuals, but, as Lamarck insists in the cases he mentions, it affected all the individuals over a large area. Those individuals with incipient limbs became erased or

[1] Certain footprints recently discovered in the Upper Devonian show that the type had become established then, at least vertebrates with legs and toes.

[2] Parker and Haswell's *Text-Book of Zoölogy*, vol. ii, p. 220.

swamped, and we find no trace of them in the strata yet examined.

Thus far, indeed, paleontology is silent [1] as to the mode of origin of the amphibian limb, as it is concerning the origin of arthropod limbs from the parapodfa of annelids. Unfortunately, and this is still a weak point in the evolution theory, nowhere do we find, unless we except the Archæopteryx, clear examples of any intermediate forms between one class and another; each species, as far as its fossil remains indicate, seems adapted to its environment.

There are numerous cases of vestigial structures, but no rudimentary ones showing distinct progressive steps in a change of function. Hence arises the very reasonable view held by some that nature may make leaps, and that new adaptations or organs may be suddenly produced. No inadapted plant or animal as an entire organism has ever been observed either among fossils or existing species. Man has some seventy vestigial structures, but his body as a whole, notwithstanding the disadvantages of certain useless vestiges, is in adaptation to his physical and mental needs.

While the true Carboniferous labyrinthodonts were few and generalized, with gills and four legs, already in the Permian, where we meet with some thirty forms in the Ohio beds alone, and about as many in Bohemia, a great modification and specialization had taken place. Forms like Peleon and Branchiosaurus had gills and four legs; others were like our lizards, as in Keraterpeton; Dendrerpeton and Hylonomus of Nova Scotia were more lizard-like and with scales; others, perhaps, swam by means of paddles, as in Archegosaurus; others, like the "Congo snake," were snake-like, with small, weak legs,' as Œstocephalus; some had gills but no legs, as in Dolichosoma, while in others the limbless body was snake-like and scarcely

[1] Paleontology is also equally silent as to the origin of pleisosaurs and ichthyosaurs from their terrestrial digitigrade forbears; though in Archæopteryx we have an unusually suggestive combination of reptilian and avian features. Certain Theriodontia point with considerable certainty to the incoming of mammals such as the Echidna and duckbill, but as to the steps which led to the origin of brachiopods, echinoderms, trilobites, of Sirenians and of whales, paleontology affords no indications.

larger than earthworms, as in Phlegethontia of the Ohio and Ophiderpeton of the Bohemian coal measures.

Already, then, in Permian times the stegocephalous type showed signs of long occupation, old age, and degeneration. The process of degeneration and reduction in, and loss of, limbs may have been initiated as far back as the closing centuries of the Devonian.

The effect of the Appalachian revolution and corresponding physical changes in Europe was by no means disastrous to the Stegocephala, for those of the Liassic, where the conditions must have been more formidable to terrestrial vertebrate life, were abundant, and in some cases at least colossal in size. Whether the salamanders, cœcilians, sirens, and Amphiuma of present times are persistent types, survivors of Carboniferous times, or whether the process of modification has been accomplished a second time within the limits of the same class, is, perhaps, a matter for discussion.

Besides the introduction and elaboration of the air-breathing, four-footed labyrinthodonts, the sloughs and sluggish streams were alive with Naiadites and its allies, forerunners of the Unionidæ, and with them lived shelled phyllopods, Estheria having already appeared in the Devonian, Leaia appearing in the Carboniferous; and also the larvæ of aquatic net-veined insects, fragments of the imagines of which were detected by Hartt at St. John, New Brunswick.

The coal-bearing strata are largely fresh-water beds of fine shale, and well calculated to preserve the hard parts of delicate animals, but on general grounds it is evident that the great extent of lowlands with extensive bodies of fresh water communicating with the shallow sea was most favorable to the development and differentiation of terrestrial life. Though fresh-water and land shells (pulmonates) appeared in the Devonian, they were apparently more abundant in the coal period. Especially rapid was the incoming of the arthropods; both diplopods, some of them very remarkable forms, and chilopods lived sheltered under the bark of colossal lycopods; with them were associated scorpions, harvestmen, and spiders. The great profusion of net-veined insects discovered at Com-

mentry, France, shows that this was the age of the lower, more generalized, or heterometabolous insects, such as cockroaches, and other Orthoptera, of Eugereon, may-flies, and possibly dragon flies, etc., our wingless stick insects being then represented by winged ancestors. At this time also began the existence of insects with a complete metamorphosis, as traces of true Neuroptera and the elytra of a beetle have been detected in Europe. But thus far no relics of flowers or of the insects which visit them have been discovered in Carboniferous times, not even in the Permian, so that the origin of insects with a complete metamorphosis, such as moths, ants, and flies, may be attributed to the new order of things, geographical and biological, immediately following the Appalachian revolution.

We do not wish to be understood as implying that the origin of new orders and classes is directly due to geological crises or cataclysms themselves.[1] On the contrary, the initial steps seem to have been taken as the result of the gradual extension of the land masses, and the opening up of new areas; it was the period of long preparation, with long-continued oscillations, the slowly induced changes resulting from the reduction of the mountainous slopes to peneplains, which were most favorable to the gradual modification of forms resulting in new types, the gradual process of extinction of useless and senile forms, and the modification and renewal of those which became adapted to the new geographical conditions.

It should be borne in mind that this extension of the low coasts of the continents began in Ordovician times, but the remarkable expansion of our continent after the Appalachian

[1] I find that Wood has already expressed the same idea more fully, as follows: "Both in the Paleozoic and Secondary periods, therefore, the complete changes in the fauna which marked their termination do not appear to have been immediate upon the changes of the geographical alignment, but to have required the lapse of an epoch for their fulfillment; and the completeness of that change is perhaps not less the indirect result of the altered alignment, by the formation of continents where seas had been, and the opening out of new seas for the habitation of marine animals, thereby causing a gap in the geological records so far as they have been hitherto discovered, than the direct result of the changed conditions to which the inhabitants of the seas, and even those of the land, came to be subject on account of the entire change in the alignment of the land over the globe." (*Phil. Mag.*, vol. xxiii, 1862, p. 281.)

revolution, rather than the upheaval of the plateau itself, so favorably affected plant and animal life that at the dawn of the Mesozoic a great acceleration in the process of type-building was witnessed. Moreover, it seems evident that the variation which took place at this epoch was by no means fortuitous, but determined along definite lines caused by the definite expansion of the continents, and their resultant topography.

We have seen that as a result of the folding and upheaval of the Appalachians there may have been at the beginning of Triassic time, in addition to the tropical lowlands, a somewhat cooler upland zone, and possibly even snow-clad mountain peaks, with glaciers descending their sides, as we may now witness in New Zealand.

Already on Permian soil reptiles were not infrequent. They were generalized composite forms comprising the Proganosauria, the forerunners of the Hatteria of New Zealand, and the Theriodontia, from which the mammals are now supposed to have been derived. They disappeared at the end of the Triassic, together with the labyrinthodonts, from which the reptiles are thought to have originated. These reptiles having scaly bodies and claws, their habits must have been like those of the lizards of to-day, and they were adapted for hotter and drier, perhaps more elevated, areas than the stegocephalous amphibians ; and these conditions were fulfilled in Triassic and Jurassic times, when the reptilian orders multiplied, all the orders of the class having been differentiated, or at least were in existence, in the Mesozoic era.

The geographical features throughout the Mesozoic were these : more or less dry and broad plains, vast fresh-water lakes, uplands clad with coniferous forests afterwards to be replaced by forests of deciduous trees; flower-strewn plains overgrown with waving grasses, and jungles with rank growths of bamboo. We can, without going into detail, well imagine that the geographical features of the Mesozoic continents were such as to provoke the appearance of the higher classes of vertebrates. As the land rose higher and the low swampy coastal areas became more limited, this would tend to restrict the habitat of the stegocephalous amphibians ; with a slightly

more elevated and drier coast, the incoming and expansion of reptilian life were fostered ; with still higher plains and hills, besides the increasing abundance of flowers and other seed-bearing plants and of the insects which visit them, existence for birds became possible, and with them that of a few scattered mammals of small size and generalized structure, with similar insectivorous habits.

During the age of reptiles, when they swarmed in every jungle, throughout the forests and over the plains, competition rose so high that some of them were forced to take flight, and bat-like, provided with membranous wings, the pterodactyls lived in a medium before untried by any vertebrate, and finally there appeared in the Ornithostoma of the Cretaceous a colossal flying reptile, its wings spreading twice as much as any known bird, with a head four feet in length, its long toothless jaws closing on swarms of insects or perhaps small fry of its own type. But the experiment, in point of numbers or capacity for extended flight, did not succeed. Another type assayed the problem with better success. There appeared feathered and eventually toothless vertebrates, with the fore extremities converted into pinions and the hinder ones retaining the raptorial reptilian form better adapted for aërial life. They eked out a by no means precarious existence on flying insects and seeds; as well as on the life in the soil or by the seaside, and rapidly replaced certain older reptilian types. The class of birds has become about four times as numerous as the reptiles, and outnumbers the mammals nearly six times.

We may now review the zoölogical changes which took place at the time including the end of the Paleozoic and the opening of the Mesozoic. There was an extinction of the Tetracoralla and their replacement by corals with septa arranged in sixes ; an extinction of cystidian and blastoic crinoids, the dying out of old-fashioned crinoids and echinoids (Palæocrinoidea and Palæechinoidea), followed by the rise of their more modern specialized successors. As rapidly as the brachiopods became diminished in numbers, their place at the sea bottom was taken by the more active and in some cases predatory bivalve and univalve mollusks. As the trilobites became extinct, their

place in part was filled by their probable descendants, the Limuli, which had already begun to appear, the earliest types being Neolimulus, Exapinurus, and other forms of the Silurian, and Protolimulus of the Devonian. The Limuli of the Carboniferous, some with short (Prestwichia and Euproöps) and others with long tail spines (Belinurus), suggest long possession of the soil and consequent variation and differentiation.

The Eurypterida shared the fate of the trilobites, and while there was a thorough weeding out of the more typical ganoids, leaving an impoverished assemblage to live on through after ages, that singular primitive vertebrate group, the Ostracodermi, was wholly obliterated.

On the other hand, with the incoming of a new order of vegetation a great outgrowth of winged insects, the representatives of the orders of Lepidoptera and Hymenoptera, now so numerous in species, began their existence.

By the close of the Appalachian revolution, probably all the orders of insects had originated, unless we except the most modified of all, the Diptera, whose remains have not been detected below the Lias. With but little doubt, however, the eight orders of holometabolous insects diverged in the Permian, if not near the close of the Carboniferous, from some protoneuropter, the progress in the differentiation of genera and families becoming rapid either during the Jurassic or directly after the lower Cretaceous, or as soon as grasses and deciduous trees became in any way abundant.

Very soon, too, after the close of the revolution, the ancestral birds and mammals diverged from the reptiles, and of the latter the turtles, plesiosaurs, ichthyosaurs, crocodiles, and dinosaurians, and soon after the pterodactyles, came into existence.

As a result of this revolution the molluscan type was profoundly affected, as, at the opening of the Triassic, siphoniate Pelecypoda, opisthobranchiate Gastropoda, and cuttles or belemnites appeared. While a few orthoceratites lingered on after the revolution, the ammonites blossomed out in an astonishing variety of specific and generic forms.

In summing up the grand results of the Appalachian revolution and of the times immediately succeeding, we should not

lose sight of the fact that the changes in the earth's population were due not less to biological than to geological and topographical factors. The process of extinction was favored and hastened by the incoming of more specialized forms, many of them being carnivorous and destructive; as, for example, nearly all fishes and reptiles live on other animals. The struggle for existence between those which became inadapted and useless in the new order of things went on more actively than at present. The process of extinction of the higher, more composite amphibians (the labyrinthodonts) was largely completed by the multitude of theromorphs and dinosaurs which overcame the colossal Cheirotherium, Mastodonsaurus, and their allies.[1]

During the centuries of the Trias the lowlands became crowded, and the reptilian life was forced in some cases to gain a livelihood from the sea, for at this time was effected the change from small terrestrial reptiles like Nothosaurus to the colossal plesiosaurs and ichthyosaurs, in which digitate limbs were converted into paddles; and the ocean, before this time uninhabited by animals larger than ammonites, cuttles, and sharks, began to swarm with colossal vertebrates, the increased volume of their new and untried habitat resulting in a tendency to a corresponding increase in weight, just as whales, which possibly evolved from some land carnivore in the early Tertiary, waxed great in bulk, the increase in size perhaps having been due to the great volume of their habitat, the ocean.

Nothing so well illustrates the advantage to an incipient type as entering a previously uninhabited topographical area, or a new medium, such as the air, in the case of the pterodactyles, the first vertebrates to solve the problem of aërial flight. Originating and prospering in the early Mesozoic, they held

[1] After writing the above lines I find the same view expressed in Woodworth's *Base-Levelling and Organic Evolution.* He remarks: "The exact cause of their decline is probably to be sought in the development of the more powerful reptilia" (p. 225). Regarding the circumstances favorable to reptilian life, he also states: "In the development of the peneplain from the high relief of the Permian and again at the close of the Jura-Trias, the widening out of the lowland, with plains and jungles, near tide-level, followed by depression of the land, must have highly favored the water-loving reptilia. It is to these geographical circumstances, I think, that we must look for our explanation of the remarkable history of this class in Mesozoic times" (p. 226).

their own through the Cretaceous, where at their decline they became, as in Ornithostoma, colossal and toothless. We can imagine that the demise of this type was assisted in two ways: those with a feebler flight succumbed to the agile, tree-climbing dinosaurs; while the avian type, waxing stronger in numbers and power of flight and exceeding in intelligence, exhausted the food supply of volant insects, and drove their clumsier reptilian cousins to the wall, fairly starving them out; just as at the present day the birds give the bats scarcely a *raison d'être*.

3. *The Pacific Coast Revolutions.* — It has long been known that there are a greater number of insect faunæ on the Pacific coast, and greater variation of species, with more local varieties, than east of the Mississippi River. It has also been shown by Gilbert and Evermann, as well as by Eigenmann, to apply to the fishes of the Columbia and Frazer River basins. "Nowhere else in North America," says the latter, "do we find, within a limited region, such extensive variations among fresh-water fishes as on the Pacific slope." He also points out the noteworthy fact that the fauna is new as compared with the Atlantic slope fauna, and "has not yet reached a stage of stable equilibrium." As previously shown by Gilbert and Evermann, "each locality has a variety which, in the aggregate, is different from the variety of every other locality"; and he adds: "the climatic, altitudinal, and geological differences in the different streams, and even in the length of the same stream, are very great on the Pacific slope."

It is evident that the variations are primarily due to the broken nature of the Pacific coast region, and to the isolation of the animals in distinct basins more or less surrounded by high mountain barriers, with different zones of temperature and varying degrees of humidity.

As brought out by the labors of Le Conte, Diller, and Lindgren, the Sierra Nevada region has undergone cycles of denudation, and these changes, occurring later than those of the Appalachian region, have doubtless had much to do with the present diversified and variable fauna. The latest writer, N. F. Drake,[1] states that the western slope of the Sierra Nevada

[1] The Topography of California. *Journ. of Geol.*, vol. v (September and October, 1897), pp. 563–578.

"was probably once a region worn down almost to base-level or to a peneplain. By the uplift of the mountains a great fault was developed along the eastern face, and the whole Sierra crust-block tilted to the westward. The streams quickened by the uplift again set to work on the peneplain and carried it to its present condition."

Le Conte [1] states that the Sierra Nevada was upheaved at the end of the Jurassic period. This corresponded to the Appalachian revolution, which occurred at the end of the Paleozoic era.

> But during the long ages of the Cretaceous and Tertiary this range was cut down to very moderate height. . . . The rivers by long work had finally reached their base-levels and rested. The scenery had assumed all the features of an old topography, with its gently flowing curves. . . . At the end of the Tertiary came the great lava streams running down the river channels and displacing the rivers; the heaving up of the Sierra crust-block on its eastern side, forming the great fault-cliff there and transferring the crest to the extreme eastern margin; the great increase of the western slope and the consequent rejuvenescence of the vital energy of the rivers; the consequent down-cutting of these to form the present deep canyons and the resulting wild, almost savage, scenery of these mountains.

This view is further carried out by J. S. Diller, from his studies of the northern part of the Sierra Nevada, including the borders of the Sacramento Valley and the Klamath Mountains. He shows that northern California, during the earlier portion of the auriferous gravel period, was by long-continued degradation worn down to base-level conditions. "The mountain ranges," he says, "were low, and the scenery was everywhere characterized by gently flowing slopes. . . ."

"The topographic revolution consisted in the development out of such conditions of the conspicuous mountain ranges of to-day. The northern end of the Sierra Nevada has since been raised at least 4000 feet, and possibly as much as 7000 feet, and a fault of over 3000 feet developed along the eastern face of that portion of the range." [2]

According to Lindgren, the Sierra Nevada was eroded to, or almost to, a peneplain during Cretaceous times, and the moun-

[1] *Bull. Geol. Soc. Amer.*, vol. ii, pp. 327, 328.

[2] *Fourteenth Ann. Rep. U. S. Geol. Survey*, Pt. ii, p. 433.

tains elevated in a later Cretaceous period were worn down during Tertiary times merely to a gentle topography.

The other post-Cretaceous changes of this vast region are thus summarized by Scott from the results of Pacific coast geologists: in the Eocene a long narrow bay occupied the great valley of California extending northward into Oregon and Washington. At the end of the Eocene or early in the Miocene an elevation in California shifted the shore line far to the west. In the Miocene the Coast range formed a chain of reefs and islands, and at the close an upturning and elevation of the mountain range took place, though it became higher afterwards. The Coast range sank again early in the Pliocene, and the San Francisco peninsula was an area of subsidence and maximum deposition forming the thickest mass (58,000 feet) of Pliocene in North America. The mountains of British Columbia are believed to have been at a higher level than now, as it is supposed that Vancouver and Queen Charlotte Islands probably formed part of the mainland.

At or near the close of the Pliocene the Sierra Nevada increased in height by the tilting of the whole block westward. New river valleys, cut through the late basalt sheets of the Sierras, are much deeper than the older valleys excavated in Cretaceous and Tertiary times, owing to the greater height of the mountains and to the consequent greater fall of the streams. At this time the Wasatch Mountains and high plateaus of Utah and Arizona were again upraised, and the great mountain barrier of the St. Elias in southeastern Alaska was likewise thrown up. At this time also, or perhaps later, the mountains of British Columbia were probably raised still higher.[1] It will be seen from this that the present topography of the western border of our continent, including Central America and the Isthmus of Panama, belongs to a new topographic era, and fully substantiates the view that the fauna of these regions is very recent compared with that of the Atlantic border, and that the number of nascent or incipient species is much greater.

4. *The Upper Cretaceous Revolution.* — Another profound and epoch-making change occurred at the beginning of the Upper

[1] *Journ. Geol.*, vol. iv, pp. 882, 894, 897, 898. (Quoted from Drake.)

Cretaceous. In Eurasia, as Kayser states, "this was one of the greatest changes in the distribution of land and water over almost the whole earth, that is known in geographical history. Extensive areas which had for long periods been continents were now overflowed by the sea and covered with Cretaceous deposits"; the Upper Cretaceous strata in certain areas in Germany and Belgium resting directly on Archæan rocks. In America (the Dakota stage) there was also a great subsidence. The Atlantic coastal plain was submerged over what was Triassic soil, also the lowlands from New Jersey through Maryland to Florida, while the Gulf of Mexico extended northward and covered western Tennessee, Kentucky, and southern Illinois; a wide sea connected the Gulf of Mexico with the Arctic Ocean, and thus the North America of that time was divided into a Pacific and an Atlantic land, the latter comprising the Precambrian and Paleozoic areas.

As Scott states: "The Appalachian Mountains, which had been subjected to the long-continued denudation of Triassic, Jurassic, and Lower Cretaceous times, were now reduced nearly to base-level, the Kittatinny plain of geographers. The peneplain was low and flat, covering the whole Appalachian region, and the only high hills upon it were the mountains of western North Carolina, then much lower than now. Across this low plain the Delaware, Susquehanna, and Potomac must have held very much their present courses, meandering through alluvial flats" (p. 481). An elevatory movement began in the succeeding or Colorado epoch, and this was succeeded by an uplift on the Atlantic and Gulf coasts, and the continued upheaval in the interior resulted in the deposition of the Laramie brackish and fresh-water beds. There were similar widespread subsidences and upheavals in South America, the Andean chain being in large part upheaved at the close of the Cretaceous.

In the Cretaceous period there were such differences in the distribution of the fossils as to lead Römer, from his explorations in Texas as early as 1852, to consider that the resemblance of the fossils of Texas, Alabama, and Mexico, with the West Indies and Columbia, to those of southern Europe, were

due to differences of climate, a view reiterated by Kayser (p. 283). Scott also states that the Lower Cretaceous beds of Texas show faunal resemblances which ally them to the Portugal and Mediterranean beds, while the faunal relations of South American Lower Cretaceous strata are closely like those of northern and western Africa.

The biological changes at the beginning of the Upper Cretaceous were correspondingly notable. Vast forests of conifers, palms, and especially of deciduous trees, such as the oak, sassafras, poplar, willow, maple, elm, beech, chestnut, and many others, clothed the uplands, while in the jungles, on the plains, and in the openings of the forests, gay flowers bloomed. The flora must even then have been, comparatively speaking, one of long existence, because highly differentiated composite plants, like the sunflower, occur in the Upper Cretaceous or Raritan clays of the New Jersey coast. It may be imagined that with this great advance in the vegetables, the higher flower-visiting insects must have correspondingly multiplied in number and variety.

While the changes of level did not affect the abysses of the sea, the topography of the shallows and coast was materially modified, and to this was perhaps largely due the extinction of the ammonites and their allies.[1] It is not impossible that the

[1] After preparing this address, I find that Wood thirty-six years ago more fully discussed this matter, and mentions the same cause we have suggested. "This disappearance," he says, "of the Ammonitidæ, and preservation of the Nautilidæ, we may infer was due to the entire change which took place in the condition of the shores at the close of the Cretaceous period; and this change was so complete that such of the shore followers as were unable to adapt themselves to it succumbed, while the others that adapted themselves to the change altered their specific characters altogether. The Nautilidæ having come into existence long prior to the introduction of the Ammonitidæ, and having also survived the destruction of the latter family, must have possessed in a remarkable degree a power of adapting themselves to altered conditions." On the other hand, the dibranchiate cephalopods (cuttles or squids), living in deeper water, being "ocean-rangers," were quite independent of such geographical changes. Wood then goes on to say that the disappearance of the tetrabranchiate group affords a clew to that of the Mesozoic saurians, and also of cestraciont sharks, whose food probably consisted mainly of the tetrabranchiate cephalopods. "Now the disappearance of the Tetrabranchiata, of the cestracionts, and of the marine saurians, was contemporaneous; and we can hardly refuse to admit that such a triple destruction must have arisen either from some common cause or from these forms being succes-

uncoiling of the ammonites into forms like Scaphites, Crioceras, Helioceras, Turrilites, and Baculites, were originally perhaps distortions due to physical causes somewhat similar to those which produced a loosening or uncoiling of the spire in Planorbis. These variations or distortions of the pond snail, signs of weakness, the result either of pathological conditions or of senility, were due to unfavorable changes in the environment, such as either a freshening of the water or some other chemical alteration in the relative amount of alkalines and salts. The changes in the ammonites, though more remarkable, are similar to the aberrations observable in the shells of the upper and later layers of the Steinheim deposits, made known to us by Hilgendorf, Sandberger, and more especially by the detailed and masterly researches of Professor Hyatt.

In this case the Miocene Tertiary *Planorbis lævis* was supposed to have been carried into a new lake, before untenanted by these shells. Although from some unknown cause the lake was unfavorable to the production of normal *lævis*, whose descendants show the results of accidents and disease, yet, owing to isolation, which prevented intercrossing with the present stock, and to the freedom from competition, the species was very prolific, and the lake became stocked with a multitude of more or less aberrant forms constituting new species. Some of them are nearly normal, with a flat spire, others are trochiform, and others entirely unwound or corkscrew-shaped. Similar aberrations occur in *Planorbis complanatus*, living in certain ponds in Belgium (Magnon) ; in the slightly twisted planorbid *Helisoma pexata* Ingersoll of St. Mary's Lake, Antelope Park, Colorado, and in the unwound forms of Valvata first found by Hartt in Lawlor's Lake near St. John, New Brunswick, and described by Hyatt.[1] In all these cases of parallelism or convergence the aberrations seem to have been due to some unusual condition of the water adverse to normal growth. Hence, it is not impossible that the singular uncoiled or

sively dependent for existence upon each other." He also suggests that the development of the cuttles "has been commensurate with that of the cetacean order, of some of which they form the food." (*Phil. Mag.*, vol. xxiii, 1862, p. 384.)

[1] *Ann. Rep. Hayden's U. S. Geol. and Geog. Survey Territories.*

straight forms assumed by certain of the ammonites when on the verge of extinction were likewise cases of convergence, and due to weakness or senility, or at least to an unusual and unfavorable condition of the seas in which they lived.

The physical causes of extinction of the Mesozoic reptiles may also have been due to, or connected with, the changes of coast level, although signs of weakness and senility are exhibited by these. In the Como or Atlantosaurus beds referred by Scott to the Lower Cretaceous rather than Jurassic, the ichthyosaur (*Sauranodon natans*) was toothless, while the colossal Cretaceous pterodactyle Ornithostoma (Pteranodon) was entirely toothless.

The colossal Pythonomorpha, offshoots of terrestrial lizards, but with paddles adapting them for marine existence, succeeded the plesiosaurs, and may have materially aided in their extinction. Hence arises the question, Did the extinction of the marine reptiles result in, or contribute to, the great increase of teleost fishes?

Before the dinosaurs began to die out, the type in part became specialized into lizard-like, tree-climbing forms, and agile, bird-like forms. The first birds of the Cretaceous were toothed, carinate, highly predaceous forms, with a retrogressive side branch of wingless diving birds, represented by the colossal Hesperornis, but in this case the loss of teeth was undoubtedly a gain to the type, compensation for the lack of a dental armature in the seed-eating birds being shown in the elaboration of a gizzard.

5. *Geological Changes in the Tertiary.* — Here again we have, as in former periods, a succession of earth movements, subsidences in one region and elevations in another, though apparently more limited in extent than before, the oscillatory movements being rather confined to coastal areas, and involving adjacent shallow seas, there being frequent alternations of marine with brackish and fresh-water beds. As Kayser remarks, the Tertiary deposits "no longer extended unaltered over whole countries like those of older systems, but generally occupied only smaller basin or bay-like areas, filled-up inland seas or shallow gulfs" (p. 328). Towards the close of the

Tertiary the great mountain ranges of Asia and Europe, the Alps, Pyrenees, Caucasus, Himalayas, as well as the Atlas, and the Cordillera of North and South America were upheaved. The old Tertiary nummulitic beds were, in the western Alps, raised to a height of 11,000 feet, and the Himalayas to a horizon 16,000 feet above the sea, while there were corresponding elevations in western North America and in the Rocky Mountain region.

The evidence from fossils shows, what has not been disputed, that climatic zones were by this time established. In Europe the older Tertiary was decidedly tropical, in the Miocene subtropical, but the climate of Europe was somewhat lowered late in the Miocene, as shown by the absence of palms.[1] At the end of the Tertiary, *i.e.*, during the Pliocene, the earth's climate was but slightly warmer than at present. It should be here noticed that while Greenland, Iceland, Spitzbergen, and Grinnell Land under 81° north latitude were during the late Tertiary "abnormally warm," the Tertiary floras of northeastern

[1] Jaeger suggests that the occurrence in the later geological periods of warm-blooded vertebrates, protected by feathers or hair, was due to the fact that the earth then became cooler than in the preceding ages. His explanation of the origin of feathers and hair is as follows: "If the average temperature of an animal body is considerably higher than that of the surrounding media, oscillations of these media have a stimulating effect upon the skin of the animal. This leads to a tendency to form papillary chorian [*sic*] cells, and these afterwards produce hair or feathers, which represent two of the most characteristic features of warm-blooded animals." He adds that this "stimulatory effect upon the skin can only be due to low temperatures." The body temperature of the birds and mammals being high, and the covering of the hair or feathers rendering them proof against the extremes of heat and cold, we can see that there is a coincidence between this and the fact that these classes began to increase in numbers towards the end of the Mesozoic, and especially at the opening of the Tertiary, when the climatic zones began to be established. So also in the case of whales the loss of hair is compensated for by the blubber. Why, however, feathers developed in birds, rather than hair, is a problem no one has attempted to solve; though feathers of course better adapt the bird for flight; no flightless birds having such well-developed feathers as those capable of extended flight. See G. Jaeger, *Problems of Nature*, translated by Henry G. Schlichter, D. S. C., p. 66. London, 1897.

It might be suggested that the broad, vane-like surface which characterizes feathers as compared with hairs may have been due to the fact that they would better support the body in flight; this difference from scales, as well as their greater lightness, giving this sort of armature an advantage over scales on the one hand and hairs on the other.

Asia, including those of Kamtchatka, Amurland, and Saghalin, and that of Japan, "show no sign of a similar warmth, but rather point to a climate colder than that of the present day" (Kayser, p. 354).[1]

The Tertiary was apparently also a time of more or less intercontinental migrations or interchange of life-forms, which crossed the oceans over so-called continental bridges. Bering Strait was at one time such a bridge, and to explain the geographical distribution of certain forms, there is thought to have been a more or less continuous land connection between India and Africa, and between Africa and South America, and possibly in the Eocene, between Australia and southeastern Asia.

However hypothetical these continental bridges may be, we do know that Central America and the Isthmus of Panama were elevated at the end of the Miocene, and that the bridge thus formed between North and South America became an avenue for the interchange of mammals and other animals which materially modified the distribution of life in the southern and northern parts of our continent.

The elevation of the West Indies took place at this date, and these islands were peopled from the South American coast. What we already know of the rapid evolution of mollusks, insects, and mammals on these islands shows how closely dependent variation and adaptation are on isolation as well as changed topographic and climatic features.

These problems have been studied with great care in the Hawaiian Islands by Gulick, and more recently by Hyatt. As well stated by Woodworth: "With the development of the umbrella-shaped topography of the Island of Oahu the land shells have varied from a common ancestral coastal type to valley-cradled, differentiated varieties, in the upper and disjointed valleys of this dismantled, volcanic island cone."[2]

The limits of this address do not permit us to treat at length

[1] It has also been claimed by J. W. Gregory that the fossil plants of the Greenland Miocene beds may have been drifted from the southward, and that the temperature of the polar region was not so elevated as Heer has led us to suppose. (*Nature*, vol. lvi, 1897, p. 352.)

[2] The Relation between Base-Leveling and Organic Evolution: referring to T. T. Gulick's article in *Proc. Boston Soc. Nat. Hist.*, vol. xxiv (1870), pp. 166, 167.

of the wonderful changes, both geological and zoölogical, which occurred in western America during the Tertiary. They are now familiar to every one. The geological changes were very great and widespread, as shown by the elevation of the land at the close of the Miocene. Fragments of the Cretaceous sea bottom, with horizontal strata, occur in the Rocky Mountains at a point about 10,000 feet above the sea. The inland Cretaceous sea was drained off, and replaced by a series of fresh-water lakes, beginning with the Puerco, or the lowest Eocene, and ending with the Pliocene lakes.

The most salient biological features of the Tertiary are the apparently sudden appearance all over the world of placental mammals, ending, if the deposits are truly Pliocene, with the Java Pithecanthropus, and at the beginning of the Quaternary with paleolithic man.

The question here arises as to what retarded the progress in the mammalian types, although small, generalized, feeble insect eaters had originated certainly in the Triassic, and probably as early as the end of the Permian. We can only account for it by the unfavorable biological environment, by the apparently overwhelming numbers of Mesozoic reptiles, adapted as they were for every variety of station and soil, whether on land, in the ocean, in the lakes and rivers, and even in the air.

When the reptiles became partly extinct, a great acceleration in the evolution of mammals at once resulted. There were now upland grassy plains, bordered by extensive forests, which also clothed the highlands, and all the geographical conditions so favorable to mammalian life became pronounced after the Cretaceous seas were drained off.

In his admirable essay on The Relation between Base-Leveling and Organic Evolution, which we had not read until after planning and writing this address, though following the same line of thought, Mr. J. B. Woodworth suggests that mammalian life in the Mesozoic was unfavorably affected by the peneplain and by reptilian life.

"The weak marsupials or low mammals, which first appear in this country with Dromatherium in the tolerably high relief of the Trias, were apparently driven to the uplands by the more puissant and numerous

reptilia of the peneplain. Their development seems also to have been retarded." Again he says: "To sum up the faunal history of the Mesozoic alone, we have seen that *pari passu* with the creation of broad lowlands there was brought on to the stage a remarkable production of reptiles, a characteristic lowland life; and we note that the humble mammalia were excluded from the peneplain or held back in their development, so far as we know them by actual remains, during this condition of affairs until the very highest Cretaceous. At the close of the Mesozoic, the area of the peneplain was uplifted and there came into it the new life. Not only the changed geographic conditions, but the better fitted mammalia also were probably factors in terminating the life of the peneplains."[1]

After the placental mammals once became established, as the result of favorable geographical conditions of migrations, isolation, and secondarily of competition, the evolution as well as the elimination of forms, as is well known, went on most rapidly. Remains of over two thousand species of extinct mammals during Tertiary times which existed in America north of Mexico have been already described, where at present there are scarcely more than three hundred. This process of specialization involved not only the lengthening of the legs, the change from plantigrade to digitigrade, and to limbs adapted for seizing and handling their prey or food, or for swimming and climbing; the reduction of digits; the evolution of armatures, protective scales, etc.; but above all an increase in the mental capacity of the later forms, not only of mammals but of birds, as shown by the progressive increase in size of their brains; those of certain existing mammals being eight times as large, in proportion to the bulk of the body, as those of their early Tertiary ancestors. This, of course, means that animal shrewdness, cunning, and other intellectual qualities, the result of semi-social attrition and competition, had begun to displace the partly physical factors, and in the primates these may have in the beginning led to the appearance of man, a social animal, with the power of speech, and all the intelligent, moral, and spiritual qualities, which, perhaps, primarily owe their genesis to increased brain power.

The three most specialized types of mammals below men are the horse, the bats, and the whales. In the case of the

[1] *American Geologist*, vol. xiv (October, 1894), pp. 209–235.

bats, which appear in the Eocene, nature's experiment with these mammalian aëronauts succeeded to the extent that they still exist in small numbers. Late in the Cretaceous or very early in the Eocene, competition apparently forced some unknown carnivorous type to take up an aquatic life, and the great success of the incoming cetacean type, resulting in the Eocene zeuglodonts and Miocene squalodon, may have had an influence on the final extinction of the colossal marine reptiles.

6. *The Quaternary Period.* — Coming now to the glacial epoch of the Quaternary period, we plainly see that under the extreme conditions to which life in the Northern hemisphere was exposed as never before, how intimate are the relations of geology and biology.

The rise of land at the beginning of the Quaternary, which carried the land and the life on it up into a cooler zone, with a mean temperature so low that the snows remained from century to century unmelted, forming continental glaciers, excited an immediate influence on the life. There were very soon developed a circumpolar flora and fauna, originating from the few Pliocene forms, which became adapted to climatic conditions more extreme than ever before known in the world's history. While a few forms thus survived, some must have perished, though the bulk of them migrated southward.

The story told by the Port Kennedy hole, in Pennsylvania, just south of the limits of the ice sheet, is a most striking one. In that assemblage where are intermingled the bones of mammals of the Appalachian subprovince, with certain extinct forms, and those of the tapir and peccary and colossal sloths, adapted to the warmth of the Pliocene, and of the present Central American region, we can realize as never before the immediate effect of a simple though very decided change of climate on organic life.

As a result of the submergence of the land in the North Atlantic and Arctic regions during the Leda or Champlain epoch succeeding, and the consequent amelioration of the climate, there was a return of a portion of the Pliocene species to the vast area thus freed from the presence of land ice.

Another effect of change of climate due to the further upheaval, drainage, and drying up of lakes and river sources in the central portions of all the continents was the destruction of forests resulting from the drying up of the lakes and streams, the formation of vast internal desert regions, with the desert floras and faunæ and saline animals peculiar to them; these are the last steps in geological history of the origination of species, and have been taken almost under the observation of man. In the origin of species adapted to desert areas and to salt lakes, *faunæ relictæ* of the lakes on the elevated plains of Asia, South America, Africa, Sweden, and the Great Lake region, we see that geographical isolation and the absence of competition are the primary factors in the case.

In conclusion, it is, from the nature of the case, notwithstanding the imperfection of the geological record, apparent that the fullest, most complete and convincing proof of organic evolution is derived from the past history of life, from paleontology, which involves the fact of geological succession. Looking back for half a century, we see that organic evolution is a fact, and is grounded and dependent on geological evolution, and the latter on cosmical evolution. Should we ever have to abandon the principle of evolution, we should also have to give up the theory of gravitation, the principle of the correlation of physical forces, and also the conception of the unity of nature. All of these principles are interdependent, and form the foundation stones of our modern science.

The rapid summary we have given of the successive changes and revolutions in the earth's history, and the fact that they are accompanied or followed by the process of the extinction of the unadapted, and their replacement by the more specialized and better adapted, show that there is between these two sets of phenomena a relation of cause and effect.

Moreover, it cannot be denied that the formation of our solar system in the manner outlined by the founders of the nebular hypothesis, that the progressive changes in geology and the earth's topography, the gradual building up or evolution of the continents, and the increasing fitness and intelligence of the life on its surface, the final outcome being man, whose physical

development was practically completed at the beginning of the Quaternary period, and whose intellectual and moral improvement have, as it were, but just begun — the scientist, as such, can scarcely deny that this process of evolution, along so many lines and involving not only material but mental and moral advances, has gone on in an orderly and progressive way. The impression left on the mind is that all these changes, inorganic and organic, have been purposive rather than fortuitous, the result of the action of natural laws, impressed on matter by an intelligence and force outside of, but yet immanent in, all things material.

With Hutton we may say: "We have now got to the end of our reasoning; we have no data further to conclude immediately from that which actually is. But we have got enough, — we have the satisfaction to find that, in Nature, there is wisdom, system, and consistency."

Here, as men of science merely, we may pause and confess our ignorance of the first or ultimate cause of this progressive evolutionary movement pervading the material universe, and, suspending our judgment, assume an agnostic position. But the human mind, even when rigidly scientific and logical, is so constituted that few of us are satisfied to stop here. He who is most capable of daring speculation in the realm of physical or biological or philosophical thought cannot refrain from inquiring into the nature of the first or moving cause, and how the present order of things has been brought about.

As a mere working hypothesis, we are, at least most of us, compelled to assume that the present order of things, material and immaterial, is not self-evolved, but is the result of an infinite Intelligence and Will, giving the initial impulse, and dominating as well as guiding and coördinating the progressive changes, whether cosmical, geological, or biological. The fact of the survival of the fittest, of the extinction of the unfit, the conclusion that throughout the universe order has arisen from chaos or the undifferentiated, the specialized from the generalized, that the good and beautiful and true have in the past overcome and will continue to outweigh what is unfit and evil in matter, mind, and morals, at least strongly suggests that the

First Cause is not only omnipotent, but all-wise and beneficent. For evolution tends to optimism. Few working biologists are pessimistic. And thus, while science as such is concerned with facts and their relations, we can, at the end of this century of scientific effort, affirm that it need not be and is not opposed to whatever is noble, exalted, hopeful, and inspiring in human aspirations, or to the yearnings of the soul for a life beyond the present; for there certainly are, in the facts of the moral and spiritual evolution of our race, intimations of immortality, and suggestions, where absolute proof is naturally wanting, of a divinity that shapes the course of nature.

THE CONCEPTION OF SPECIES AS AFFECTED BY RECENT INVESTIGATIONS ON FUNGI.[1]

W. G. FARLOW.

THE fiftieth anniversary of the foundation of the American Association is a fitting occasion for a retrospective view of the different branches of science represented in our Society, and one would be glad to hear, from the lips of some botanist who was present at the first meeting of the Association, an account of the changes which have been brought about in the methods of botanical study and research, and of the progress which has been made in North America during the past half-century. Fifty years, however, is a long time in the life of any individual, and of those who in 1848 were young, or comparatively young, even the most favored could hardly be expected to retain their scientific activity in 1898. On glancing over the list of members in 1848, one sees the familiar names of a number of botanists, including Ashmead, J. W. Bailey, Barratt, Jacob Bigelow, Buckley, Dewey, Emerson, Engelmann, L. R. Gibbes, Gray, B. D. Greene, Edward Hitchcock, Oakes, Olney, Pickering, Thurber, Torrey, and Tuckerman. Not one of these leaders of American botany in their day remains to tell us of the Association in its infancy and to trace its development with the vividness which personal experience alone can supply.

It would be scarcely fitting in me to attempt to give a general sketch of the part which botany and botanists have played in the life of the Association; nor, remembering the review of recent investigations in botany presented by Prof. Marshall Ward at the meeting in Toronto last year, is it desirable that I should encroach on the ground so thoroughly and so interestingly covered by him. I may, however, on this occasion, be permitted to say a few words on a single question on which opinions have changed very much during the last fifty years,

[1] Address of the Vice-President and Chairman of Section G, Botany, at the fiftieth anniversary meeting of the American Association for the Advancement of Science, Boston, August, 1898.

and, avoiding a detailed history of the subject, treat it somewhat abstractly in its general bearings; for the question, you will admit, is one about which we should occasionally ask ourselves what is probably or possibly true, without, however, expecting, in most respects, to be able to reach positive conclusions. What do we mean by species? Do species really exist in nature, or are they created by us for our own convenience? As I do not pretend to be in the position of a philosopher, but approach the subject as a very commonplace sort of a botanist, the word species, as used by me, means simply species as understood by the systematic botanist, and indirectly by those working in other departments of botany who are obliged to depend to a considerable extent upon the limitations of species as defined by systematists.

The publication of the *Origin of Species* in 1859, a date which marks the fall of the old school and the rise of the new, is sufficient to show that it is not probable that any other period of fifty years in the future will have the same comparative historical importance, as far as the question of the conception of species is concerned, as the fifty years we are now commemorating. Had we asked any of the botanical members of the Association in 1848 what they meant by species, they would have replied, most of them without reserve, a few with some hesitation, that in the beginning God created all species as he intended them to be, and that, by searching, the naturalist could find them out. Just how they recognized species when they saw them would have been very hard for them to say, as they did not agree in their standards; but they would probably all have agreed in saying that the recognition of species was a matter of individual judgment, one's own judgment, of course, being better than that of any one else. The sceptic at that time could not have failed to notice the frequency with which what was home-made was confused with what was God-given. Before 1859 creation was one vast pudding, in which the species had been placed like plums by an Almighty hand, and the naturalists, sitting in a corner like greedy little Jack Horners, put in their thumbs and pulled out the plums and cried, "See what a great naturalist am I — I have found a new species!"

Probably very few of my hearers have any personal recollection of the time when not to believe that species were fixed and immutable creations was enough to make one a scientific and almost a social outcast. I recall but a few people whom I knew who held these orthodox views, for it was my good fortune to be a student in college at the time of the appearance of what was called "a new edition of the *Origin of Species*, revised and augmented by the author," published by D. Appleton & Co. in 1864. By that time the novelty and audacity of Darwin's views had ceased to cause a cold shudder, and certainly the students of my time were ready to swallow not only what Darwin had written, but to add a few little theories of their own.

The young botanist of to-day will, I think, pardon me, although my contemporaries may not, if I give a short sketch of the Harvard Natural History Society in the sixties, as showing not only how changed is the position of Natural History in American colleges, but also the attitude of college students at that day toward the then new doctrine of evolution. If the Society soon after my college days passed out of existence, its end could not be said to be untimely, for the attitude not only of the university but of the scientific public towards the study of natural history had so changed that the old-fashioned Society had no place. Those of you who go to Cambridge next Friday may perhaps see a dreary, barn-like sort of a lecture-room which now occupies the greater part of old Massachusetts Hall. In days gone by the three upper stories of the hall served as dormitories, and the lower story was occupied by the rooms of the Natural History Society, sandwiched in between those of the Institute of 1770, which then was pleased to consider itself to be a literary society, and the laboratory of the Rumford Chemical Society, which, as it emitted none of the odors characteristic of chemical activity, must be considered in my day to have been moribund, if not actually defunct.

The rooms of the Natural History Society would now cause a smile. From the low ceiling were suspended an alligator, a turkey buzzard, and such other creatures as would not fit well in the wall cases. In one corner leaned lazily a large cup sponge, a receptacle for the dust which gravity constantly supplied and

the rejecta contributed at frequent intervals by the members. Around the walls was a very promiscuous collection of birds and mammals, some shot and prepared by past members, others the gift of so-called benefactors, who, not knowing what else to do with them, turned them over to the Society. Quartz crystals and other showy but not very valuable minerals hobnobbed with skeletons, one of which, at least, must have been very useful, if one could judge by the perennial absence of some of the limbs, which had been removed, as was said, for study.

Botany was represented by a single cabinet, whose pigeonholes were filled with plants of New England, enriched by choice fragments of specimens collected by well-meaning persons in the Alps and by travelers in the Holy Land. The plants were arranged, or rather shuffled, in the case according to the wishes or necessity of the curator of the time being. We were quite eclectic in our view of botanical classification, some pigeonholes being arranged on the Linnæan system, some on the natural system, and some apparently alphabetically. Whatever real value the collections may have had, once a year they were at least ornamental. Every year the members were photographed, and the alligator, the turkey buzzard, and the human skeleton were taken down and added to the group to show that we were really the Natural History Society, and not the Hasty Pudding or the Phi Beta Kappa.

The old collections were long ago dispersed, and the little which was of value is now incorporated with the different university collections. You may perhaps be curious to know what the members of the Society did. That is easily told. They all talked, and some dissected cats. The talk was to a great extent about the origin of species, and, no matter what was the subject of the papers announced for the evening meeting, it was not often that we adjourned without dropping into a discussion of evolution. Few had really read Darwin's book, but all felt able to discuss the great scientific question of the day, in which respects, perhaps, we did not differ from some older and more learned people. Although the traditional man who is always on principle "on the other side" was not wanting, we were practically unanimous in our opinion. We all

felt that a new day had dawned; that the old view of looking at species as fixed creations, and ignoring as far as possible the significance of their tendency to vary, had been forever upset by Darwin, and that hereafter we must look to evolution as brought about by natural selection to interpret species as we now find them. Not being well informed in regard to the history of scientific opinion, we assumed somewhat hastily that before Darwin all was darkness, and we did not trouble ourselves to go back and inquire whether there were not others who had had at least glimpses of the great truths of evolution; but even had we heard that there were some before Darwin who did not believe in the fixity of species, it would still have been true that it was Darwin's book by which, practically, the world at large was enlightened on the subject.

Forty years have passed, and inasmuch as we are all evolutionists, either of the Darwin school or some related school, the question suggests itself, Is our belief in evolution merely dogmatic, like some of the theological doctrines which we believe thoroughly but which we do not allow to interfere with our daily life, or, as far as botany is concerned, has our belief modified the manner in which we treat what we call species? The mere fact that we now recognize that species have been derived from other species, and are on the way to develop into still other species, would naturally lead us to be more liberal in our treatment of them systematically than in the days when variation was almost a crime against the Almighty. Certainly, with evolution as a key to guide us, our conceptions of genera and orders ought to be far more scientific than they were.

A species has been defined as a perennial succession of like individuals; and, although no definition is perfect, I doubt whether a better definition of species has ever been invented. It is a peculiarity of definitions, however, that they all need to be defined. In the present case we must be told what is meant by the word perennial, and what is meant by like. To the pre-Darwinian, perennial, of course, meant for all time. By the early Darwinians we are not told whether by perennial they meant a hundred, a thousand, or a million years; but until at least we know approximately what is meant, we must still ask

how long must be the succession of like individuals to establish a good species. Otherwise the whole matter of the distinction between a race and a species cannot be settled practically. If there is nothing definite in writings of the time of Darwin to explain the limits of the perennial succession, we should bear in mind that the object then was to bring out boldly the salient points of evolution as governed by natural selection, and the illustrations used were taken almost exclusively from the higher animals and plants in which the lives of individuals are of such duration that it was impossible to obtain accurately the records of a large number of generations in any case. Enough was shown and cited to show from the records of comparatively few generations a general tendency, which it was assumed would be confirmed could the geological record be followed, and we can suppose that, so far as they considered the question at all, the early Darwinians took it for granted that the perennial succession needed to establish a species covered very long intervals of time. While one need not object to this method of reasoning, it is plain that the practical question of when a race or variety ceases to be a race and becomes a species was left open, and it is questions of this sort which the systematist is constantly called upon to answer.

What could be learned only slowly and fragmentarily from observations and experiments on higher plants and animals might perhaps be learned much more easily could one experiment with organisms whose cycle of life is completed with great rapidity. For this purpose one might suppose that nothing could be better than bacteria, which are easily managed in the laboratory, and whose development takes place with such rapidity that it is possible for the experimenter to watch the course of hundreds or even of a thousand generations in a comparatively short time.

The advantage to be expected from studying forms in which the development is very rapid is, however, made difficult for purposes of comparison by their extreme simplicity and the difficulty, and at times impossibility, of finding sufficiently marked morphological characters to guide us; and in the absence of such characters the bacteriologist is often forced to base what

he calls his species on physiological characters, including in that term zymotic and pathological action. By botanists, who are not specially bacteriologists, the so-called species of bacteria are not admitted to be species in the proper sense. Whether scientifically considered they are not as legitimately species as what are called species in speaking of the higher plants, is a very pertinent question. Any definition of species, to be scientifically accurate, must in its essential points apply to all plants and all animals; and if a species of flowering plant is a perennial succession of like individuals, it is hard to see why in bacteria a perennial succession of like individuals does not also constitute a species. That the individuals in bacteria are very different from the individuals in flowering plants is certainly true, but that does not affect the question of the validity of the species in the former. As far as the perpetuation of morphological likeness of the individuals is concerned, there is no doubt that it is, to say the least, as complete in bacteria as in flowering plants, and the physiological constancy has been shown by competent observers to persist in some cases for hundreds of generations. That these many generations have been produced in months rather than in hundreds of years does not, it seems to me, affect the case.

When, therefore, the botanist denies that physiological species are properly species, he is practically admitting that his own definition, the perennial succession of like individuals, is used by him in a special sense, and he does not seem to be aware that species as he limits them are artificial and not natural. The belief that species should be based on morphological rather than physiological characters rests on the assumption that the former are more likely to be inherited, and thus show the ancestry, while the latter are more likely to be the result of the temporary attempts of the organism to adapt itself to the environment. It is perhaps a question whether the grounds for this belief are as valid as has been supposed. We readily see morphological characters which have been inherited, but it is usually only by accident or experiment that we recognize the physiological or pathological qualities.

Let us turn for a moment from bacteria to Saccharomycetes,

whose characteristic function is to invert and ferment the different sugars. Here we have a group much more limited in number of species than the bacteria, but like them microscopic and rapidly growing. Although not long ago they were classified after a fashion on their morphological characters, the admirable investigations of E. C. Hansen and his followers have pointed out the important fact that these characters, taken by themselves, are less fixed, although the limits of their variation may be fixed, than certain physiological characters such as the maximum and minimum temperatures of growth, and especially the temperature at which spore formation takes place. It is in these last-named characters, rather than in the former, that the specific distinctions in Saccharomycetes are sought by those who study that group specially.

The same objection is urged by botanists in this as in the case of bacteria, that the so-called species are not species, but races. We naturally ask, races of what species? There have been many attempts to determine the origin of the common Saccharomycetes, and the question has been supposed more than once to be settled. Without intending to imply that the question is not still open to investigation, I must admit that there does not yet seem to me to be any satisfactory proof to show from what higher forms Saccharomycetes have been derived. Although there can be no doubt that in the germination of spores of certain fungi, especially the Ustilaginaceæ, bodies are produced in abundance which not only closely resemble Saccharomycetes in shape, but also, in some cases at least, are capable of producing alcoholic fermentation to a limited extent, it does not seem to me that that is by any means enough to warrant the opinion expressed by Brefeld that the Saccharomycetes are derived from, and are degenerate conditions of, Ustilaginaceæ. In fact, one has only to consult Brefeld's own writings to see that Saccharomycetes-like bodies are produced by the germinating spores of other orders of fungi than Ustilaginaceæ, and it is known that, in some species, as in the genus Aspergillus and in certain Mucoraceæ, the budding cells which look like the Saccharomycetes, using the word in the limited sense, are also capable of producing alcoholic fermentation.

On the other hand, no one has yet succeeded beyond a doubt in making the Saccharomycetes proper revert to a higher ancestral form. I say beyond a doubt, because the observations of Juhler, Joergensen, and Johan-Olsen, on the relation of Aspergillus, Sterigmatocystis, and Dematium, to Saccharomycetes, have not been confirmed by other equally good observers, as Kloecker and Schioenning; and, for the present at least, we must regard the observations of Joergensen and Johan-Olsen as affording still other instances of the fact that under proper conditions the germinating spores of many fungi produce bodies like Saccharomycetes, while they do not show conclusively that forms recognized by specialists as genuine Saccharomycetes can be transformed into fungi of other orders. They do, however, show that the views of Brefeld that the Saccharomycetes are derived from Ustilaginaceæ could, at the best, be only partially true.

Let us return to the question as to whether or not species of the Saccharomycetes, as defined by Hansen for instance, should be allowed to be called species in the proper sense of the word. Of course no one supposes that they have always existed in their present form, and, although we have no exact knowledge of the ancestors of the present species, we naturally suppose that they were derived from some other higher fungi, as the expression goes. Whether derived from one particular order of fungi or from several different orders, the species as we now see them seem to be constant in the sense that that word must be used in speaking of species of any group of plants. The shape of the cells in any given species, although variable to some extent, is constant within definable limits, and, although they have periods of rest and periods of activity, their physiological action seems to be the same under similar conditions.

We might be justified, it seems to me, in regarding as races the Saccharomycetes-like forms which result from the germination of spores of higher fungi, provided they continued to live an independent existence for a time and were not, as is more likely to be the case, merely accidental conditions depending on unusual or unfavorable conditions of germination, but the Saccharomycetes in the limited sense are constant, as far as

constancy is to be expected in living organisms in general; they cannot be made to revert. as far as we know, and I therefore fail to see why they should not be admitted to be scientific species. The same is true of the physiological species of bacteria, meaning, of course, those which have been well studied, and excluding the mass of ill-described and ill-known forms which abound in bacteriological writings. When a race has become so constant that it no longer reverts, and we cannot tell from what species it came, it is no longer a race, but a species.

It may be objected, however, that both bacteria and Saccharomycetes differ from ordinary plants in a most important respect, *viz.*, that there is a complete absence of sexuality and the reproduction is purely vegetative. There are a few botanists, to be sure, who think that there is a form of sexuality in Saccharomycetes, but botanical opinion at present is so overwhelmingly on the other side that to call the question an open one would require an explanation which time will not permit. It may be urged that in plants in which sexuality is wanting we have no right to speak of a perennial succession of like individuals, for, it may be claimed, succession means by sexual generation only. This interpretation is very convenient if one wishes to ignore forms like bacteria and Saccharomycetes in the consideration of the question of species, but to exclude them on this ground is somewhat dangerous unless we are prepared to admit, offhand, that species are purely artificial.

It is the custom to speak of bacteria and Saccharomycetes as degenerate forms. What is meant by this expression is not plain, unless it means that, arising presumably from plants in which sexuality was present, they have become non-sexual. Undoubtedly sexuality is the rule in nature, but it should be borne in mind that it is not universal. I do not refer here to fungi like Ascomycetes and Basidiomycetes, which, accepting the hasty conclusions of the Brefeld school, have been, even by a good many of our own botanists, included in the limbo of non-sexual degenerate forms, from which more recent observers are gradually rescuing them. I refer rather to species like *Rhodymenia palmata*, one of the commonest red seaweeds of the North Atlantic, in which, so far, nothing has been discov-

ered but the non-sexual tetrasporic reproduction. This is not an isolated case, and others will probably occur to my hearers. Furthermore, we must admit that the number of species normally sexual, but in which apogamy sometimes occurs, has been perceptibly increased by the studies of botanists in recent years. In such cases as that of Rhodymenia it may be that the cystocarpic fruit really exists, and will be found later, but, since botanists have searched for it in vain for many years, it must be very rare, and certainly, as far as we know it, the plant is non-sexual.

In regard to cases of apogamy, we have not yet sufficient data as to their capacity for propagating themselves continually apogamously, although in such cases as that of *Chara crinita*, if we may judge by the distribution of the species in central Europe, there seems to be no reason to believe that they may not do so indefinitely. The not inconsiderable number of species of mosses, some of them common species, in which the male or female only is known, and the number of marine algæ, which, in spite of their frequency, bear only tetraspores, or at most bear cystocarps very rarely, should make us cautious in so defining what we mean by species as to imply that we consider that the perennial succession refers only to succession by sexual generation.

We cannot fail to notice an increasing tendency among cryptogamic botanists to give more and more weight to physiological characters in limiting their species. For some time we have been accustomed to think of the species of bacteria as largely physiological, and we are gradually accustoming ourselves to the views of those who hold the same view in regard to species of Saccharomycetes. More recently still we find that in another higher order of fungi, the Uredinaceæ, experts are coming more and more to rely on physiological characters. If in bacteria and Saccharomycetes we have plants which are generally recognized to be non-sexual, in Uredinaceæ the probability is that there is sexuality; at least, the probability is here much stronger than in the other two groups. By some the sexuality of Uredinaceæ is considered already proved, but admitting that the form of nuclear union demonstrated by Dangeard and Sappin-Trouffy, and confirmed by some other botanists, must have some impor-

tant significance, not only in this but in other orders of fungi where it occurs, there are reasons for not regarding the union in this case as representing true sexuality. On the other hand, although no one has as yet quite proved it, there appear to be reasons for supposing that, in the æcidial stage, a form of true sexuality occurs, comparable with what is known in some ascomycetous fungi. Time alone will show whether this present probability is a reality, but at any rate the position of Uredinaceæ in regard to sexuality is undoubtedly very different from that of bacteria and Saccharomycetes.

One who takes up the recent descriptive works on Uredinaceæ is surprised to see the number of species which depend on physiological characters. The former method of describing the species of this order from the morphological characters of the teleutosporic, the uredosporic, and æcidial stages, was certainly sufficiently perplexing, but one almost gives up in despair on seeing species in which the different stages are identical in all respects, except that some of them, usually the æcidia, will grow only on certain hosts. Facts like this are of course only determined by artificial inoculations, although they may sometimes be suspected by the distribution of the different stages in nature. In this complicated state of things, more complicated than in any other order of plants, we are compelled to examine very critically the accounts of cultures made even by botanists of high reputation, and it is only natural that we should hesitate to give implicit confidence to negative results unless the observations have been repeated by other observers at other times and places. Even from scattered positive results one should avoid drawing too wide general conclusions. We may readily believe that some of the supposed distinctions in the choice of their hosts by different Uredinaceæ will be proved hereafter not to be founded in fact, but, making all proper allowances for possible errors in observations and for hasty speculation in a field where speculation is so easy, and accurate experiment so difficult, we have to admit that in a good many cases surprising results have been confirmed by repeated observations, and the tendency to split up species on physiological grounds becomes more and more marked.

As the subject is somewhat complicated, it will be well to consider a few prominent cases by way of illustration. An instructive case is that of the Puccinia on *Phalaris arundinacea*, referred to, among other subjects, by Magnus and Klebahn in papers published in 1894 and 1895. To the teleutospores was originally given the name *Puccinia sessilis* Schneider, which was found by Winter to bear its æcidia on *Allium ursinum*. Later Plowright experimented with a species which grew on Phalaris whose teleutospores could not be distinguished from those of *P. sessilis*, but whose æcidia could be produced on *Arum maculatum*, though not on Allium. To this physiological species Plowright gave the name of *P. phalaridis*. Still later Soppit discovered that a Puccinia indistinguishable from *P. sessilis* and *P. phalaridis* in its teleutospores produced its æcidia on *Convallaria majalis*. To this species he gave the name of *P. digraphidis*. Had these observations not been confirmed by others we might have doubted whether Winter, Plowright, and Soppit had not really experimented with the same species of Puccinia, but, owing to some accident of their cultures, had succeeded in inoculating only different hosts, whereas it might well be the case that the æcidia on the three hosts might by subsequent cultures prove to be the same ; and, in that case, *P. sessilis* would really be only an instance of a Puccinia which produces æcidia on three different hosts, not an infrequent case. The observations of Magnus showed that *P. digraphidis* bore æcidia also on Polygonatum and Maianthemum, genera closely related to Convallaria. So far as concerned Polygonatum and Maianthemum, Soppit and Magnus's observations were confirmed by Klebahn. The case is complicated by a difference of opinion as to whether the æcidium on Paris is connected with *P. digraphidis*, or whether there is not a fourth distinct species, *P. paridis*, as believed by Plowright.

We need not stop to consider the further history of this complicated case, as it is introduced here merely to illustrate the method and tendency of recent workers in this field.[1] The above-named botanists, who studied the species of Puccinia on

[1] Those interested in the subject should consult Klebahn, "Ueber den gegenwärtigen Stand der Biologie der Rostpilze," in *Botanische Zeitung*, May 16, 1898.

Phalaris, seem to agree in speaking of *P. sessilis*, *P. digraphidis*, and *P. phalaridis* as distinct species, although Plowright considered *P. paridis* to be distinct from *P. digraphidis*, whereas Magnus considered the two to be what he calls adaptive races (Gewohnheitsracen) of the same species. Magnus speaks of the three species as biological species, which he distinguishes from adaptive races, the latter including forms in which, although the æcidium may be produced on different hosts, it does not appear to be so frequent or so well developed on some hosts as on others, showing in the one case that the adaptation is more complete than in the other. Klebahn, although admitting that it is not of real importance whether one regards such forms as the Pucciniæ on Phalaris as species or races, nevertheless states that he sees no reason why they should not be considered to be genuine species rather than races.

Another instance in point is the group of æcidia generally known as species of Peridermium, which infest species of Pinus. It had for some years been recognized that the æcidial stage of the corticolous form of *Peridermium pini* was not the same as that of the form on the leaves, but in recent years the subdivision has been carried much farther, owing to cultures made by Klebahn, Edouard Fischer, Rostrup, and others. The former has distinguished at least seven species of Peridermium on *Pinus sylvestris* alone, whose uredo and teleutospores are to be found in the species of Coleosporium, which grow upon different genera of Compositæ, Scrophulariaceæ, and Campanulaceæ. Although Klebahn is inclined to see minor differences in the shape and markings of the æcidial spores of some of the species, it must be admitted that the differences in some cases are so slight, both in the case of the æcidial spores and the corresponding teleutospores, that, were it not that cultures show the connection between the form on one host with that on another to the exclusion of other hosts, it is hardly likely that many botanists would consider them as distinct species.

The most suggestive Uredinaceæ for our present purpose are the different species of Puccinia which attack grains and other grasses, for a knowledge of which we are indebted to the

researches of Eriksson and Henning in Sweden, whose work is certainly a model of careful investigation. I take it for granted that most of my hearers are already acquainted with the character of the work in question, and we need stop to consider only those points which bear upon the subjects we are discussing. Of the three common rusts which affect grains, *Puccinia graminis*, *P. rubigo-vera*, and *P. coronata*, the æcidia are to be found, respectively, in *Æcidium berberidis*, *Æc. asperifolii*, and *Æc. rhamni*, according to the previously accepted view in regard to those species. Judging by the morphological characters of the teleutospores and the uredospores alone, these three species occur on a large number of different grasses. In making inoculations to ascertain the facts in regard to the æcidia of the species, Eriksson and Henning found that what was supposed to be *P. graminis* growing on *Phleum pratense* and *Festuca elatior* had no æcidia, and they described this form under the name of *P. phlei-pratensis*. *Puccinia coronata* is separated into two species, *P. coronifera* and *P. coronata*, the former having its æcidium on *Rhamnus catharticus*, the latter with æcidia on *Rhamnus frangula*, with perhaps two other forms to be separated from the old *P. coronata*. *Puccinia rubigo-vera* is separated into three species : *P. glumarum*, *P. dispersa*, and *P. simplex* — the distinctions based largely on the presence or absence of the æcidium, although there are also certain differences in the habit and color of the other stages. The three original species are split up into seven species, besides two uncertain forms, characterized in the main by physiological characters. Furthermore, of *P. graminis*, six specialized forms are enumerated, characterized by differences in the inoculating capacity of the uredo or teleutospores on different hosts. The other species also have their specialized forms, the total number being, I believe, twenty-eight. We may consider the specialized forms to be races, and, in that case certainly, we shall have to agree with Eriksson and Henning in considering their seven species as species rather than races. The important point is to know whether the differences observed are temporary and accidental or permanent. It is too much to ask for the confirmation of the results of these two experimenters just

now, for their work is recent and has been carried so far beyond that of previous experimenters that it must require a considerable number of years before we can expect the work to be repeated by others. So far as the experiments have been repeated, as in the case of *P. coronifera* and *P. coronata*, it has been confirmed.

Enough has been said to show that the conception of species by those who are doing the most advanced work in fungi is much more flexible than it used to be, and significance is to be attached to the fact that the number of those who, as viewed by the typical systematic botanist, hold very heterodox views is increasing. The explanation is to be sought in the fact that descriptive botany in certain groups of plants has reached a point where the ordinary morphological characters no longer suffice to classify what we know or wish to know about the plants themselves. It was my privilege eleven years ago to address what was then the biological section of the Association on a subject somewhat related to that of to-day, and my closing sentence then was: "Following the prevailing tendency in business affairs, the question they [botanists] ask of plants is not so much, 'Who is your father and where did you come from?' as, 'What can you do?'"

The tendency noticed eleven years ago is even more marked at the present day. As compared with the times of which I attempted to give a sketch in my opening remarks, I think we may truly say that whatever may be the case in zoology, in botany theoretical considerations with regard to evolution play a much less important part than they used to. In the case of such plants as Lycopodiaceæ, Equisetaceæ, and their allies, and of certain orders of phanerogams, the ancestral question naturally remains as important as ever; but, although papers on other orders of plants, accompanied by hypothetical genealogies and family trees of the banyan type, appear at not infrequent intervals in botanical journals, they are quite overshadowed in general interest by the papers on cytology, life histories, and physiology. That was not the case in the sixties, when nothing compared in interest with the question of the origin of species. While we cannot be too grateful to Darwin for having opened

our eyes to see the value of evolution in general, the majority of the active botanists of the present day find too many other pressing questions to be solved to be able to dwell on evolution to the same exclusive extent as did the botanists of the last generation.

Our definition of a species included two terms which required further explanation. We started out in the hope of finding some light as to the approximate length, or at least the approximate minimum of the length of time which is needed to transform a race into a species, hoping that perhaps those plants in which the development of the individual was rapid might show that in a comparatively short space of time a race might be actually observed to become fixed and be considered a species; a fact which certainly could not be so well ascertained by direct observation in the study of the higher plants alone. You will notice that, like the obliging shopkeeper, I have not given you exactly what you expected, but have offered you instead something else perhaps just as good, if not better. If I have not been able to tell you that in such simple and quickly growing plants as bacteria and Saccharomycetes new species can be produced from old ones in a comparatively short time, a consideration of some of the peculiarities of such plants has brought out the modifications which have taken place in the views of a good many as to specific limitations, which is in part an answer to our primary question, What do we mean by a species?

It may be added that although some of the species of lower plants may be transformed in various ways by artificial cultures, on the whole we are quite as much struck by their comparative constancy in important respects as by their tendency to differentiate. In Uredinaceæ there is a tendency to form adaptive races, which is greater than was formerly supposed; but whether the tendency is greater than would be found in some higher plants, were they studied as carefully as have been the Uredinaceæ, is perhaps a question. Parasites, as a rule, are more plastic and more sensitive to changes of environment than other plants, and their impressionability, if I may use that word, might be expected to accentuate their power of specific transformation. It cannot be denied that there is a general suspicion, to say knowl-

edge would be too strong, that the lower plants become specifically changed more easily and quickly than the higher; but although this is what we should expect from their more rapid individual growth, I am not able to cite any actual observations which can settle the question ; for, as you know, the school of botanists, which may be called the school of ready transformationists, have a fatal tendency to accept unskillfully conducted or otherwise faulty observations as convincing proofs. Others, it is to be feared, err on the other side, and are not sufficiently ready to admit metamorphoses in different species of the lower plants. Probably the truth lies between the two. The metamorphoses to which I now refer are, of course, in the normal cycle of individual development and should not be confused with the differentiation into races and species, but of necessity our views as to the latter must be influenced to some extent by our attitude towards the former.

If we turn to the second word of our definition which needed explanation, and attempt to say what is meant by like individuals, we find ourselves wholly at sea. Even if we agree that the likeness must be morphological and not physiological, that does not help the matter at all. No two individuals are ever absolutely alike in morphological characters, and the question is one of comparative likeness only. Systematists may agree that certain characters are more important than other characters, but they would never agree as to what characters are important enough to be regarded as specific in comparison with those which are only racial. In fact, when we come to the point, we find that most systematists do not in practice distinguish species from races on the ground that the former are practically constant, whereas the latter are not, but rather on the ground that they regard the characters which they use to distinguish species as more important than those which they are willing to accept as merely racial.

But what is more important and less important is a question not only of individual opinion at any given time, but it is also a question which depends on the means of analysis at our disposal, and these change from time to time. Surely there never lived a better systematist than Elias Fries, and at the time of

its publication, in 1821–32, his *Systema Mycologicum* was certainly a masterpiece. If the species described by him in genera, such as Sphæria, for example, which were then considered valid, are no longer recognized as such, it is not because in limiting his species as he did Fries did not employ with remarkable skill the same scientific principles of classification as the mycologists of to-day, but mainly because the modern application of the microscope to the study of the spores and some other characters has brought out facts unknown at the beginning of the century. The species of Fries have been split up and changed in many respects, and while we feel sure that the modern classification, thanks to improved microscopes, is an improvement on his, who shall dare say that hereafter some present unknown and unsuspected method of analysis may not furnish facts which will overturn our present system?

I should feel that I ought to apologize for bringing up a subject so very, very threadbare, were it not that some botanists shrink from acknowledging the fact that what we botanists call species are really arbitrary and artificial creations to aid us in classifying certain facts which have been accumulated in the course of time, and nothing more. So long as we entertain even a lingering suspicion that they are anything more, systematic botany will not be able to accomplish its real object, which is certainly very important. We are all convinced, theoretically at least, that not only are all plants gradually changing, and sooner or later will no more be what they now appear to us to be than they are now what they were in times past, and we also know that the means which we have of studying them are changing as well. Our so-called species are merely snapshots at the procession of nature as it passes along before us. The picture may be clear or obscure, natural or distorted, according to our skill and care, but in any case it represents but a temporary phase, and in a short time will no longer be a faithful picture of what really lies before us; for we must not forget that the procession is moving constantly onward, and at a more rapid rate than some suspect. Better cameras will be invented, and when another generation of bota-

nists snap off their pictures, they will undoubtedly look back with pity, if not with contempt, on our faded and indistinct productions.

Whether or not species really exist in nature is a question which may be left to philosophy. Our so-called species are only attempts to arrange groups of individual plants according to the best light we have at the moment, knowing that when more is known about them our species will be remodeled. We should not allow ourselves to be deluded by the hope of finding absolute standards, but it should be our object to arrange what is really known, so that it can be easily grasped and utilized. Utility may, perhaps, sound strange, and may seem to some to be a very low aim in science, but in the end utility will carry the day in this case, for systematic botany is a means, not an end. Its true object should be to map out the vegetable kingdom in such a way that all known plants are grouped as clearly and distinctly as possible, in order that the horticulturist, the forester, the physiologist, may be able to obtain the facts needed by them in their work. Our present knowledge may not be sufficient to enable us to draw all the contours sharply, or to lay down accurately all the lines, but our work certainly should not be blurred by subtleties and purely metaphysical refinements. The best systematist is not he who attempts to make his species conform to what he believes to be the ideal of nature, but he who, availing himself of all the information which the histology, embryology, and ecology of the day can furnish, defines his species within broad rather than narrow limits, in clear and sharply cut words which can be readily comprehended and do not force one to resort to original and perhaps single specimens to learn what the author of the species really meant.

The end which we all wish ultimately to reach is a knowledge of how living plants act; but in the process of obtaining this knowledge it is necessary to call to our aid not only the physiologist, but also the systematist and the paleontologist; for there are many questions ultimately to be settled by the physiologist for which the information furnished by the systematist must serve as a basis, and the geological succession must be

supposed to throw some light on present conditions. It is no disparagement to systematic botany to say that it should look towards physiology as its necessary supplement; for, on the other hand, physiology must lean on systematic botany in attempting to solve many of its problems, and the scientific basis of both rests on histology, morphology, in the modern sense, and embryology. The qualifications needed in a physiologist are so different from those required in a systematist that no one is warranted in speaking of one as of a higher grade than the other. If it has become the fashion in some quarters to assign the systematist to a secondary place, it cannot be attributed to the fact that his work is necessarily inferior in quality, but is rather due to the fact that in too many cases systematists have failed to recognize what should be the legitimate aim of their work.

The utilitarian tendency is well shown by what has been said in speaking of bacteria and Saccharomycetes. Did time permit, and were the subject not one which would not readily be followed with patience by an audience at this late hour, other instances, especially in Ustilaginaceæ, might be given to illustrate further the point in question. The bacteriologist bases his species on grounds which he thinks best suited to enable him to group together intelligently the plants he is studying, and it is nothing to him that others say that his species are not species, but races. After all, the question whether certain forms are to be considered species or races is in many cases merely a question of how much or how little we know about them. The races of one generation of botanists often become the species of the next generation, who, as they study them more minutely and carefully, discover constant marks not previously recognized. As systematic botany develops in the future, it may very well become the study of races rather than species as we now consider them. In some cases, as in the Uredinaceæ, the time may be not far distant when this condition of things will be reached. We also feel warranted in believing that hereafter physiological characters will assume even a greater importance than at present in the characterization of species. If there are some among my hearers who do

not agree with me as to the importance to be attached to utility, I think that we shall all agree that in discussing the work of botanists in other departments than our own, it would not be wise to exact a rigid conformity to our individual conceptions of species as distinguished from races.

NOTES ON SOME EUROPEAN MUSEUMS.[1]

EDMUND OTIS HOVEY.

WHEN the author was in Europe last year, for the purpose of attending the Seventh International Geological Congress, he improved the opportunities which presented themselves for visiting museums, paying especial attention to the departments of geology, mineralogy, and palæontology. On his return a somewhat detailed report on these matters was prepared for the authorities of the American Museum of Natural History, and this has been thought of sufficient general interest to warrant its publication. The order of presentation is essentially geographic, being very nearly that in which the museums were visited by the author. This discussion cannot claim to be complete, because the museums at Vienna and Munich are not included, these cities lying too far away from the route traversed to permit of being visited in the time at disposal.

Hildesheim. — This quaint mediæval city of northern Germany contains a large and valuable collection of various material in a confiscated monastery which has been remodeled to adapt it to museum purposes. It is called the "Roemer Museum" in honor of the public-spirited citizen who endowed it. Regarding the general museum there is not much to be said. There is much fine material on exhibition, but the general scheme of arrangement and classification and the installation are hampered by the limitations of the old monastery buildings. The director has, however, succeeded in bringing the geological department up to a high state of perfection and interest. The collection illustrating general geology consists at present of only about 350 hand specimens of rocks, but these are selected and displayed in such a manner that they give at a glance a very good idea of the most striking phenomena of the science. The collection in the cases is well supplemented by diagrams, charts, and photographs hanging upon the neighboring walls. The

[1] Read before Section E at the fiftieth anniversary meeting of the American Association for the Advancement of Science, Boston, August, 1898.

phenomena of nature thus illustrated embrace the action of mountain-building forces, of water, wind, and sand upon rock surfaces, and of volcanic activity of various kinds. The use of pictures is not only instructive, but is an addition to the attractiveness of the exhibit, and serves to call the attention of visitors to the specimens in the cases. The collection is well provided with descriptive and other labels. As proved by experience at Hildesheim, and also at the Natural History Museum in Paris, and at the Museum of Practical Geology, and the British Museum (Natural History) in London, such collections illustrating general geology may be made not only instructive, but attractive and somewhat popular as well. Here, even more than in some other departments of natural history, the popularity of the exhibit will depend largely upon the effectiveness of installation and arrangement and the clearness and completeness of labeling.

The Rock Collection embraces more than 1000 specimens on exhibition, and, besides igneous and other crystalline rocks, includes samples of sandstones, limestones, and other sedimentary rocks. The specimens consist, for the most part, of well-trimmed blocks about six by four by one to one and a half inches in dimensions. They are arranged in trays, and each is accompanied by a neat, clearly written, comprehensive label. The classification is according to a scheme of which the tabulated elaboration lies at convenient points in the cases, and may also be obtained with the printed guide. That such a collection of rocks is highly valuable to the student for systematic study goes without saying; but it is also useful to the general public for reference, because the knowledge, and consequently the literature, of the subject of petrography is rapidly increasing at the present time, and the inquiry for such collections is also on the increase. Wooden-framed cases are used exclusively throughout the museum.

Berlin.—The famous mineral collection of the Natural History Museum is arranged partly in wooden-framed cases with "A"-shaped tops, the exhibition specimens being arranged on narrow steps in these tops, while the base is provided with drawers for systematic storage. The cases display the minerals in an excel-

lent manner, but they are too high. The specimens on the top step are too far up for any but a very tall man to inspect, and such high cases interfere with the architectural effect of the room without any compensating gain in installation. Between the high cases there are narrow, flat-topped table cases, which contain the small, fine specimens and isolated crystals of the collection, the classification being strictly in accordance with that of the high cases. In the table cases white pasteboard trays with green edges are used to hold the specimens, and the effect is not pleasing; in the "A" cases the specimens rest directly upon the step shelves, which have raised edges. The inside of the "A" cases is painted a light color (either white or gray). Wire supports of various shapes are much used for the proper display of specimens, and with excellent effect. The large collection of meteorites and the mineral specimens which are too big for the cases are disposed about the hall without reference to classification.

The labels are all written by hand with India ink. An expert penman is employed for the work, and the labels are handsome in appearance, and less expensive there than printed labels would be. Such labels are in use throughout the museum, and are strongly to be recommended on account of their durability and appearance. To return to the mineral collection: the group labels are put into neat nickel frames which stand about four inches above the trays or the shelf. The individual labels are laid in trays in the table cases, but in the "A" cases are tacked to the front of the step, just beneath each specimen. Very few of the labels contain anything but the name of the species and the locality from which the specimen came; thus, "Fahlerz, Müsen, Westphalen." When the mineral has a "common name" recognized in Germany, that alone is used, as in the instance cited. Chemical formulæ, statements about crystalline form, etc., are relegated to the group labels. When specimens have come to the museum from some large or noted collection, that fact is indicated on the label.

The petrographic collection consists of representative hand specimens of all important kinds of rocks, arranged in table

cases, and is provided with many brief explanatory labels in addition to the individual label accompanying each specimen. Such phenomena as the effect produced on adjoining rocks by the heat of the igneous rocks when erupted or injected are fully illustrated by large, handsome specimens which have been very carefully collected and prepared for exhibition. The cases in this department also have wooden frames. The catalogue of each of these departments is in book form, and although a general catalogue has not yet been prepared, each specimen bears an accession number of such a kind that its exact location in the collection or in the storage drawers can be told at a glance.

Palæontological Collections. — The remains of animals and plants are in separate rooms. The collection of fossil animals is merely synoptic, only fine specimens being on exhibition, and includes vertebrates and invertebrates in one series, the arrangement being zoölogical. The hall is badly lighted, which greatly impairs the effect of the wonderful assemblage of fossil reptiles. Upright and table cases are used for the small and the particularly valuable specimens, but most of the large reptiles are displayed without any covering, except that some of them have a wire netting over them. The collection of fossil plants is in a well-lighted room. The specimens are very fine, and show that a collection illustrating palæobotany may be made attractive as well as instructive. A noteworthy feature of this room is a series of transparent sections of plants, mounted between glass plates and suspended in front of the windows, where one may readily examine them. This arrangement is not confined to the Berlin museum, however, and may be adapted to several classes of objects, *e.g.*, agates and corals.

Invertebrate Zoölogy. — The hall of invertebrate zoölogy is cased with iron-framed upright cases, which are about seven feet high and so arranged as to divide the room into alcoves. While a great amount of well-lighted exhibition space is thus obtained, the architectural effect of a large hall is lost by the arrangement. A new and very effective feature is a series of rectangular jars containing illustrative life groups in alcohol. Some of the groups represented are oysters and their surroundings,

mussels and theirs, and squids. In the molluscan collection many of the species have alcoholic preparations of the entire animals displayed in the cases beside the corresponding dry shells. Most of the insects on exhibition are in very shallow glass-covered boxes, which are held in frames in such a manner that they may be removed at will. These frames form "A"-shaped tops on table cases. Wings are mounted between glass plates and hung in the windows. A termite nest, more than six feet high, is one of the striking objects in this department.

Russia. — Although I visited museums in St. Petersburg, Moscow, Kazan, Perm, Nijni Tagilsk, Ekaterinburg, Kychtym, Oufa, Kharkow, and Tiflis, all can be dismissed with a few words, because, as a rule, the methods of installation in vogue are not to be recommended. Poorly lighted halls prevail, with flat-topped table cases and high upright and wall cases. These are usually made of pine, with small panes of glass, and inadequate protection from dust. The collections cannot be said to be well classified, except at the universities of Kazan, Moscow, and Kharkow, and at Tiflis. Commendation, however, rather than blame should be rendered the authorities of the smaller towns, because something, at any rate, has been done to get together and preserve objects of interest from the district in which the museum is located, — which is more than has been done by most towns of similar size and importance in countries which consider themselves ahead of Russia in such matters. The evils of faulty classification are illustrated in the mineral collection of the Imperial Mining Institute, in St. Petersburg. This collection has a world-wide reputation for the marvelous size, perfection, and beauty of some of its specimens, but it is difficult to find some of the most noted of these, because the minerals seem not to be arranged according to any system of classification that is recognized in western Europe, England, or America, even those of the same species not being kept together. Labels and locality cards are lacking from a large part of the collection, rendering it in so far useless to the average visitor and greatly lessening its value to the mineralogist.

Naples. — The only geological and mineralogical collections in Naples that are accessible to the public are contained in the

university buildings. They are primarily educational in purpose and are systematically arranged. They contain many fine specimens, among which may be mentioned a grand fossil palm from the Vincenza beds, near Verona, a volcanic "bomb," eighteen or twenty inches in diameter, from the crater rim of Vulcano, one of the Æolian islands, and a leucite crystal, nearly four inches in diameter, from Rocca Monfino. Flat-topped table cases with wooden frames are used in the geological rooms; in the mineralogical rooms such cases are supplemented by upright cases, in which, as so often happens, the upper shelves are far too high for utility. The specimens in the geological rooms are displayed in pasteboard trays, unless they are too large for this method of installation, while those in the mineralogical collection are mounted for the most part on wooden blocks. The Vesuvian collection of the celebrated mineralogist, Prof. C. Scacchi, is preserved in a separate room, to the detriment of the main collection. Such separate collections are the bane of a museum, interfering as they do with the uniform arrangement of the collection on a systematic plan.

Geneva.—The university at Geneva possesses a good museum of natural history in a well-lighted wing of its main building. The departments of geology, mineralogy, conchology, and invertebrate zoölogy, are the best. The rock collection is comprehensive, as one would expect it to be on the borders of the Alps. The hand specimens are displayed in white wooden trays with projecting bases for the labels. The effect is rather clumsy on account of the thickness of the edges of the trays. The de Saussure collection of quartz crystals from the Alps is famous and contains many fine specimens, but it is not well displayed, and poor installation detracts from any collection, no matter how beautiful the specimens may be. The Delessert collection of recent molluscs is here, containing many of Lamarck's types, but the types are not distinguished by means of a noticeable mark, as such important specimens should be. The shells are gummed to cards, a practice which is objectionable on account of the danger of fracture when the shell must be removed from the case for any purpose. The source from which the specimen has come to the museum is indicated by a

letter in the upper left-hand corner of the card on which the shell is mounted. Only a synoptic collection of the shells is on exhibition, — a very few examples of each species and not many species under each genus. In this museum again the upper shelves in the upright cases are much too high for the exhibition of anything but very large specimens which do not require close examination. The fossil shells are placed as near as possible to the groups of recent shells to which they are related.

Paris. Jardin des Plantes. Mineralogy. — The mineral collection is divided into three parts: the general collection; several special collections; some large specimens out of series. The classification recently proposed by Prof. P. Groth, of Munich, is followed in the general collection, with some modifications in minor details. The installation is not modern, the cases being narrow flat-topped table cases surmounted by shallow upright cases, and fully one-fourth of the collection being on shelves too high to be seen with any degree of satisfaction, if at all. Since, however, plans for a new building have already been drawn, it is not worth while to go into an extended criticism of what will soon be discarded. The system of labeling is very complete, each label bearing the name of the species or variety, with one or more synonyms, the chemical formula, the system of crystallization, the mode of occurrence, the locality, and the donor. The peculiar feature about the labels is the statement as to the mode of occurrence, and it is a good one. I quote a sample label from the printed visitor's guide to the collection:

THORITE.

Synonymes : *Thorine silicatée.*
Variétés : *Orangite, Uranothorite.*

Formule Chimique :
$Th\ Si\ O_4$.

Système Cristallin :
Quadratique.

Nature des Gisements :
Pegmatites, Syénites néphéliniques.

The italicized portion of the label is written in by hand, the rest being printed. The specimens are mounted on painted wooden blocks of a pearl gray color. The effect is rather cheap. The labels rest on pins on the sloping fronts of the blocks. Minerals like ruby silver, horn silver, the bromiodides, etc., which are liable to injury from exposure to direct sunlight or to very strong diffused daylight, are placed under covers made of orange brown glass. These, of course, do not improve the appearance of the cases, but they preserve the minerals, and they may be readily removed for the benefit of a student. The foundation of this general collection was laid more than a hundred years ago, hence it has had considerable time in which to grow to its present high state of perfection as to the number of species represented.

Special Collections. — There are seven of these: *A.* Collection of the minerals of France and her colonies. This contains in particular the types described in "The Mineralogy of France," by A. Lacroix, each species, however, being represented by only two specimens. The primary arrangement is by districts. *B.* Technological series. Under this head are brought together those minerals, cut or polished, which are used for ornamental purposes, jewelry, bric-a-brac, etc., such as agate, jade, jadeite, fluor spar, pagodite, etc. *C.* Collection to illustrate the occurrence of minerals. In the general collection the minerals are considered merely as minerals, but in this new collection they are regarded from the point of view of their formation, and are classified according to their occurrence and association in nature. This is a highly instructive and very interesting series, but thus far there have been placed on exhibition only the minerals of igneous rocks, those of sedimentary rocks which have been metamorphosed by contact with igneous rocks, and those of certain calcareous bands in gneiss. *D.* Collection of cut precious stones. The principal specimen in this gem collection is a beautiful blue sapphire weighing 132 carats and cut in rhombohedral form. The series of diamonds comprises about seventy-five crystals. The beauty of the gem collection is marred by its unsatisfactory installation. *E.* The Bischoffsheim collection of diamond crystals. This is kept separate from the

main gem collection. *F.* Collection of artificial minerals. This is in process of formation, a start having been made with a magnificent set of artificial rubies, which were manufactured by the Frémy-Verneuil process. *G.* The Haüy collection. This collection, which has great historical value, comprises several thousands of specimens labeled by the hand of the celebrated founder of crystallography, and is retained just as he left it. The great collection of meteorites is displayed in a case by itself. Most of the small specimens are mounted in wire holders attached to blocks. A printed label on the front of each block gives the history of the specimen in brief, *i.e.*, the kind of meteorite, the date of fall, when known, and the locality where found.

Geology. — The collection to illustrate stratigraphical geology occupies a series of flat-topped table cases running down the middle of the room containing the mineral collection. It is very full in specimens illustrating the geological features of central Europe. The Archæan is illustrated by means of specimens about 4 × 6 inches in size, of the principal varieties of rocks and of some of the results of dynamo-metamorphism. For the succeeding ages a synoptic collection of fossils is exhibited, together with specimens showing kinds of rocks, dynamic phenomena, etc. The arrangement is primarily chronologic, and under that is geographic. Plaster casts are introduced when good fossils are not available. Light-colored pasteboard trays are used for the specimens. The labeling is very complete. The gallery also of the mineral hall is devoted to geology, and contains a very large rock collection, besides the series of specimens upon which Daubrée and other French geologists have made their classic studies in experimental geology. In this part of the room also the labeling is very satisfactory. The cases, however, are far from dust-proof, and fully one-fourth of the geological as well as the mineralogical exhibit is too high or too low for satisfactory inspection.

Palæontology. — The extensive and important collections of vertebrate and invertebrate fossils occupy the main floor in a new building in the Jardin des Plantes, which was not yet open to the public at the time of my visit. Without going into a

detailed discussion of these celebrated collections, brief mention may be made of some points in their installation. The whole effect is rich, handsome, and pleasing, no expenditure of time or money having been spared by the government or the scientific *attachés* of the department to render the appearance of the hall as attractive as possible. Some might even say that this effort had been carried too far, characteristic French taste having been allowed full play. Tables and desk cases are of oak, and all are comparatively small. The exhibition part of the desk cases has a bronze frame, the bottom of which is covered with silk velour of a reddish terra-cotta color, and most of the specimens are mounted on tablets of heavy manila board ($\frac{1}{8}$ or $\frac{5}{32}$ inch thick) of a light brownish terra-cotta color. As a rule, the large specimens are placed directly upon the velour background without the use of tablets. Simple, handsome supports made of brass wire are much used in both the desk and the upright cases for mounting specimens in the proper attitudes. Minute specimens are cemented to glass squares or rectangles backed by cardboard of the same color as the velour, and the whole placed on the top of a wire support. As far as practicable, at least three specimens are used to illustrate each species of bivalve molluscs, an entire individual being fastened to the middle of the tablet in front, and the opposite detached valves being raised on wire supports on each side of it. Whenever needful or desirable, the specimens have been cut and polished to show the internal structure. The bronze-framed tops are excellent in that they are very tight and dust-proof, and that the frame presents the least possible obstruction to the light and to the view of the visitor, but those in the hall in question are hard to open, and they do not overhang the lower part of the cases. To have the upper part of a desk or table case project beyond the sides of the base for a certain distance (about four inches) is important, because exhibition space is gained thereby, visitors can see the specimens with greater convenience, and the bottom of the case is preserved from injury by boots. The upright cases have iron frames and a bolt lock similar to, if not identical with, the familiar Jenks lock. The backs of these cases are painted a

terra-cotta color of the same shade as the velour in the desk cases. The shelves are of plate glass, with the exception of the bottom one, which is of wood. The matter of labeling has been very carefully attended to, but types and figured specimens are not as prominently marked as they should be in every collection. The arrangement of the fossils is primarily stratigraphical, and then zoölogical by geographical provinces.

L'Ecole des Mines. — The collections of this famous school in all departments of geology are enormous. Wooden-framed cases are used throughout, but the installation is not very recent, and the writer does not know what the feeling of the authorities is toward cases with metal frames. The mineral collection is well labeled, but the classification is such that it is very difficult for a visitor, even though he know something of mineralogy, to find a given species. An attractive feature of the collection is the polished thin sections of minerals, such, for example, as agates, which are framed between glass and hung in the windows. There are many large, showy specimens in the collection, and these, for the most part, are arranged out of series in small rooms. They rest upon blocks, and are provided with printed labels. They are in high wall cases. There is a large and very interesting suite of artificial reproductions of minerals, representing the labors of Daubrée, St. Claire Deville, and others. The table cases have flat tops, and the specimens in them are displayed in pasteboard trays. The meteorite collection consists of small fragments, and is in white trays with blue edges. As would be expected in a mining school, materials of economic importance are well represented in the cases.

In the geological department the general rock collection is apparently very complete, and contains many handsome specimens. It is well arranged in upright cases, but it is defective in point of labels, and therefore is nearly useless to a visitor. The collection to illustrate general geology is very full, and is well arranged and labeled. It consists of a synoptic collection of rocks and fossils, and is classified by geographical provinces as well as by zoölogical subdivisions, under the primary stratigraphic arrangement. The best collection of all in point of

classification, and also in the manner of mounting the specimens, is that of palæontology. The arrangement is primarily zoölogical, and the completeness of the collection in certain departments, *e.g.*, Cephalopoda and Hippuritidæ, is impressive. Most of the specimens are mounted on tablets of manila board, some being kept in place by pins and some by cement. Very small specimens are attached to cards, which are then inserted into glass specimen tubes or vials, where they may be readily examined without being handled, and without danger of loss. The table cases are high and narrow from front to back, and have flat tops. The glass tops are arranged so that the front and sides are lifted up when the case is opened, leaving the specimens exposed as if they were on the top of a table. It is claimed that this is convenient, and that it renders the cases more nearly dust-proof than the usual method of opening. A device that may be recommended to museums in which the storage drawers under the cases were not provided with sliding glass tops when they were built is in use here. It is to groove (rabbet) the upper edge of the drawer all around, so that a glass plate of the right size may be slipped in as a cover. Thumb holes should be provided in the rabbet on two sides of the drawer to facilitate the removal of the glass cover.

London. The British Museum (Natural History).—A volume could be written about the methods of installation employed in different parts of this great institution. So many ideas have been tried here, and information on all points regarding desirable and undesirable methods of installation is so freely given by the officers in charge of the various departments, that it is not too much to say that this is the most important place in Europe for a person to visit who desires to learn what to do and what to leave undone in a museum. I can mention within the limits of these "Notes" only a few of the more striking features of the departments studied.

Palæontology. — Specimens are never crowded, much stress being laid upon the idea that it is better to have first-class specimens well displayed than it is to have all the material in the museum out on exhibition. Printed explanatory labels are full and numerous, and much use is made of drawings, diagrams,

and models, in the cases beside the specimens, to help to a clear understanding of structure. As examples of this feature, mention may be made of the crinoids, the brachiopods, and the cephalopods. Glass models of living cephalopods and corals are used in connection with the labels, explaining the structure of those groups of animals. Gaps in the series on exhibition are filled by drawings until the desired specimens can be obtained. Type and figured specimens are carefully and prominently marked with discs of emerald green paper gummed to them. Manila board tablets about $\frac{5}{32}$ of an inch thick, with light cream-colored surface, are now used in the cases. Pins are used for the most part instead of cement for keeping specimens in place. Species are divided off by means of strips of wood. The lower part of upright cases is utilized by putting in a false back and secondary shelves which bring the specimens close to the glass. None but large specimens, which do not require close inspection, are placed on the upper shelves of the upright cases. The drawers under the table cases are provided with sliding glass tops which protect their contents from dust and at the same time permit easy general inspection. The new floor cases have "A"-shaped tops, and for some forms of fossils which can be permanently attached to cards or mounted in trays or glass-topped boxes, these cases are excellent. A false bottom brings the specimens directly beneath the glass into good position for observation. All the cases have mahogany frames, metal frames not having found favor yet in this museum. The arrangement of the collection is primarily zoölogical, but under the zoölogical subdivisions the specimens are arranged according to geologic age and geographic provinces. A very large part of the material on hand is not on exhibition, being stored in accessible drawers as a study collection. The series of fossil plants is a very noteworthy portion of the department. One large gallery is devoted to the stratigraphic collection of British sedimentary rocks, and to nine collections of historic and palæontologic interest bearing upon the early history of the British Museum, and the study of geology and palæontology in Great Britain. The stratigraphic collection gives a continuous section of the sedi-

mentary deposits, from the most recent on the east coast to the most ancient on the west, and includes numerous small sections of the strata observed and recorded by various geologists in different parts of England. There is also a series of small maps, colored to show the exposed area of each geologic formation, and placed next to the case containing the specimens illustrating that formation. The most important of the nine "type" collections are those bearing the names of Sowerby, Gilbertson, S. V. Wood, F. E. Edwards, and Thomas Davidson. The last three alone would be enough to establish the preëminence of the museum in invertebrate palæontology.

Mineralogy.—The collection of minerals is probably the finest and most complete in the world. The aim of the trustees is to show all the definite mineral species that are known, in all their varieties of crystalline form, modes of occurrence, and associations with one another. They also aim to have specimens from all noteworthy localities, and it is a "special object that examples of each mineral species show its most complete development, whether in magnitude or perfection of crystals, in the color and limpid purity, or in any other important quality which may belong to it in its more exceptional occurrence." In a wall case just outside the entrance to the main mineral gallery there is a very attractive display of polished samples of some of the rocks and minerals which are used for ornamental purposes. The main hall or gallery is cased entirely with mahogany desk cases, except for four mahogany wall cases, two at each end of the room. The mineral collections include a series introductory to the study of minerals, embracing a set of specimens illustrating the growth of some of the ideas now considered fundamental in the science, and other sets of fine specimens showing the characters of minerals (their crystalline form, color, lustre, degree of transparency, streak, cleavage, etc.), and illustrating the terms used in their description; the systematic collection of species and varieties; enclosures in minerals; a series of crystals, natural and artificial; and a large number of pseudomorphs. The mineral specimens which are too large for exhibition in the desk cases are installed in wall cases in a room called the "pavilion," beyond

the main gallery. This pavilion also contains the collection of pseudomorphs and paramorphs, the Ruskin collection of forms of silica, and the famous collection of meteorites.

The specimens in the desk cases are mounted on tablets, and are never crowded. These tablets are of wood, with a very narrow rim, which is painted black. The main portion of the block is covered with a sheet of the finest quality of jeweler's cotton wool, which is held in place by being forced down into a groove provided for the purpose just within the raised rim. These tablets are very effective in appearance; they do not change color, and dust does not show readily on them, and specimens are not apt to slip on them. Group labels, and labels for particularly showy specimens, are printed with pen and India ink on white celluloid plates of appropriate size, and attached to the blocks on which the specimens rest, or are raised on suitable supports. When there are many specimens of the same species, they are grouped together within strips of wood of a given color. The use of these strips of colored wood gives a means of ready and rapid comparison. The strips are painted different colors on the two sides, so that one strip may answer for a partition. Minerals like proustite, the bromiodides, etc., which are liable to injury by long exposure to strong light, are covered with neat wooden boxes bearing the name of the species on the outside. Persons desiring to examine such specimens get permission to do so on application at the office of the department. A cloth screen rests on the top of the cases over other minerals which it is desirable to keep in the shade. This may be removed and replaced by the visitor himself. To provide against leaving cases unlocked, the locks are so arranged that the key cannot be removed from them without throwing the bolt. Cut gems are displayed in their systematic position in the general collection, there being no special "gem cases." The gem of the gems is a South African diamond crystal of very symmetrical form, weighing 130 carats. Much use is made of wire holders and supports for getting specimens into proper position for display. The system of classification followed is essentially that based on chemical composition and crystalline form, propounded by

Gustav Rose in 1852. Recent additions are exhibited for a time in a case provided for the purpose, before they are distributed in the general collection.

The great collection of rocks is arranged in the Mineral Gallery, on account of the close relationship between minerals and rocks, and consists of the regulation hand specimens about 4 x 6 inches in size, mounted on tablets in desk cases, and large specimens illustrating rock masses, installed in wall cases at one end of the room. A new feature of the collection, and one of the highest importance in such a branch of science as petrology, is the series of specimens introductory to the study of rocks. This series illustrates the gradual development of the science, and the terms used in the description of rocks as far as is practicable by means of specimens. Printed descriptions are displayed beside the specimens, so that they supplement each other in a very clear manner. It is not likely that the general public takes very much interest yet in such collections of rocks, but the demand for information on the subject of petrology is on the increase, as is shown by the testimony at the various museums mentioned in these notes, in which rock collections are on exhibition, and especially where the general collection is supplemented by an adequate introductory and explanatory series of specimens.

The series of guidebooks published by the British Museum is a highly commendable feature of the institution. These little books, of which fourteen are now issued for the various departments of natural history, are valuable aids to any one examining the collections. A few of them are intended merely as indexes to the collections described, but most of them are veritable text-books in popular though accurate language introductory to the department of science treated, making the most direct use from page to page of the specimens on exhibition in the cases. They are models of what explanatory guidebooks should be, and their prices are so low as to bring them within the means of all persons interested.

The Jermyn Street Museum.—The "Museum of Practical Geology," in Jermyn Street, contains the collection of the Geological Survey of the United Kingdom. In scope it is

confined to the British Isles and, as its name indicates, it seeks to show, as far as possible, the bearing of geology on everyday life. It contains much to illustrate the use of geological materials in art and industry, hence there are many manufactured articles on exhibition. The building is far too small for the proper display of the exhibition material on hand, and, therefore, the authorities cannot carry out their ideas regarding installation. The palæontological collection is very rich, and is arranged, as closely as may be, to illustrate the geological map of the kingdom in process of preparation by the survey. As at the British Museum, the types and figured specimens are marked by means of little discs of emerald green paper gummed conspicuously to them. The effect of a large part of the excellent collection of building stones is injured because the cubes are displayed in desk cases. Stratigraphic geology and petrology occupy a room together. The case introductory to the general rock collection contains a series of specimens to illustrate the meaning of the commonest terms employed in describing rocks, supplemented by enlarged microscopic drawings of thin sections of rocks. Such enlarged micro-drawings are also displayed beside many of the hand specimens in the general collection. A very interesting case in this room is that in which are displayed specimens to show the effects upon rocks of the surface action of various agents, such as ice, wind, and water. Photographs and other pictures form a very valuable adjunct to this series. In another compartment of the case one may see the effects which highly heated and molten rocks have produced upon the rocks with which they have come in contact. Cut gems are not wholly separated from the mineral species to which they belong, but are displayed in the case containing the principal show specimens of the mineral collection. The Ludlam collection is a series of very choice mineral specimens mounted on blocks in flat-topped, bronze-framed cases. New acquisitions to any department of the museum are displayed for a time by themselves before they are distributed to their permanent places.

Cambridge. The Woodwardian Museum. — The famous collections in this museum are so crowded into an unsatisfactory

building, that one gets very few hints as to general installation. The collections are entirely geological and palæontological, and the material is magnificent, especially that collected and prepared by Mr. Henry Keeping. Types and figured specimens are very carefully preserved, and a list of them was prepared and published as an octavo volume of 180 pages in 1891. These specimens are mounted on tablets of a different color from those used for other specimens. At one time pink was used, but now dark blue is employed. This method distinguishes the types with great readiness, to be sure, from the other specimens in a case or drawer, but it produces a bizarre effect upon the appearance of the collection, and specimens are in danger of losing their identity, if they are removed from their tablets for any reason, or if they become detached through accident. The tablets are made of manila board about $\frac{1}{8}$ of an inch thick. Specimens loaned to go out of the building always have a distinctive museum label gummed to them before they are taken away. The drawers used for storage and study collections are provided with sliding glass tops. Many interesting problems have been worked out or illustrated by means of the material in this museum; one of these is the arrangement of certain series of specimens to show the insensible gradation between related species and genera. Inasmuch as this museum is intended primarily for the student and the investigator, most of the collections are arranged with their convenience directly in view. The museum has a few special collections which must be kept together intact, by the provisions of their donors. The museum authorities have been striving for years to procure funds for a new building, and it is to be hoped that they will succeed before anything injurious happens to the valuable material under their care.

In closing these brief notes, the author wishes to disclaim having any thought that they are complete. He has not undertaken to mention all the good features of the museums visited, but has only tried to present some of the salient points that presented themselves in an all too hurried tour. Among the general considerations that come up most prominently out

of the mass of notes are the following: India ink is the only suitable medium to use for preparing pen-written labels, and great care must be exercised in the selection of type for printed labels, so that they may be readily and perfectly legible. Celluloid makes a handsome material on which to prepare certain showy labels, though some object to it on account of its inflammable nature. Certainly numbers of celluloid plates ought not to be stored together anywhere about a museum. Labels for individual specimens should be concise, clear, and brief, while those for groups should be more explanatory in character. Series introductory to the general collections are of the highest value in a public museum, and should be well supplied with diagrams, figures, charts, and explanatory labels, to make their meaning clear to the average visitor. Brass wire is a most useful thing for making supports of all forms for specimens and labels. The top and bottom shelves of most upright and wall cases can be well utilized only for large specimens and masses which do not require close inspection. Wooden blocks can be used to good advantage for the installation of specimens only in upright and wall cases, and then are best adapted to minerals. Tablets of manila board from about $\frac{5}{32}$ of an inch in thickness are an excellent mount for most fossils, though trays and glass-covered boxes and glass tubes are necessary for some forms. The manila tablets should be covered with paper of some light color that will not fade. Light cream color is now being used in the British Museum, but French gray is considered by most persons to be the most durable color. White is not at all lasting. Fragile specimens, or those with a thin epidermis, should not be cemented to tablets, but should be kept in place by means of pins. In general, it is best to mount specimens in such a manner as to permit of their ready removal for close examination or study. Metal frames for cases have found much favor on the Continent of Europe, and they certainly have a great advantage in that the framework presents the least possible obstruction to light and vision; but they are difficult to make and to handle, and they do not produce as good an achitectural effect in a gallery as wooden cases.

EDITORIAL.

Georg Baur. — In the recent death of Prof. Georg Baur, of Chicago University, science in America has met with a severe loss. In fact, since the death of Professor Cope there has been no one in our country who had a more extensive and a more accurate knowledge of vertebrates, living and fossil, than he. He came to America thoroughly trained by those masters, Leuckart and Zittel, and from his coming here until his death his work was continuous and important. The amount of work which he accomplished in his early years in this country is known only to few, but these few are fully aware that his contributions, especially to the study of fossil reptiles, were both numerous and of the highest importance. He was in reality the victim of that system against which this journal has always protested — he was not allowed to publish his discoveries over his own name. When the release came, Baur at once stepped into prominence, and had time spared him, he would soon have stood, in popular esteem, among the world's first paleontologists.

For many years Baur has been a firm friend of this journal. Many have been the contributions from his pen, but their value is to be estimated rather by their character than by their number. With the reorganization of the *American Naturalist* he was invited to assume charge of the department of vertebrate paleontology, and we felt that with his aid we would be able to maintain the high standard in that department which the journal had under Professor Cope. Continued ill-health, however, interfered with that active participation which he had expected to give. It was hoped that his return last spring to his home in Munich might bring renewed vigor, but he did not rally. The *American Naturalist* mourns its loss.

We are indebted for the following account to his brother-in-law, Ernst L. C. Schulz, of Munich, Bavaria : —

Born Jan. 4, 1859, at Weisswasser, Bohemia, where for a time his father was professor of mathematics, Georg Baur passed his youth in Hessen and Württemberg. He went through the Gymnasium at Stuttgart, and in 1878 entered the University at Munich, taking up especially the study of paleontology, geology, zoölogy, and mineralogy. In 1880 he went to Leipzig, where he studied under Credner and Leuckart. Two years later he returned to Munich, and there "made" his Doctor of Philosophy. He remained in Munich from 1882 to 1884 as the assistant of Professor von Kupffer, to whom he

was very much attached, and who in turn honored him with his friendship. In 1884 Dr. Baur accepted a call to Yale University, as assistant to Prof. O. C. Marsh. He resigned his position in 1890 to accept a place as Docent at Clark University, of Worcester, Mass. A year later, in 1891, he succeeded, after great difficulties, in organizing an expedition to the Galapagos Islands, leaving in May, and returning in October with a most valuable collection of the flora and fauna of these interesting islands. In 1892 he was called to Chicago University as assistant professor of comparative osteology and paleontology; he was made associate professor in 1895.

It was in September, 1897, that a serious breakdown of his health gave the first indication of mental overwork. Ever since the beginning of his career Dr. Baur had always been so intensely devoted to his studies and researches that almost no leisure hours remained for recreation (143 separate publications testify to his industry). A vacation of a few months, mostly spent at one of the pretty Wisconsin lakes, seemed to benefit him. Returning to Chicago in December, the physicians recommended either a sojourn in California or in Germany. The wish to be near his relatives made him decide for the old home, and with his family he left for Europe, the University generously granting a further leave of absence. The gravity of his illness (paralysis), already suspected in America, was at once recognized at Munich. The disease made such rapid progress that not many weeks after his return from a short stay in Southern Tyrol the transfer to an asylum was made necessary. The patient was not to suffer long; he died on June 25, not yet forty years of age, leaving a widow and four children.

The family have received many touching expressions of sympathy. At the grave Professor von Kupffer spoke feelingly, referring to "the great talents, the keen perception, the untiring industry of the departed, by which he had created for himself an honored place in anatomy and paleontology. Though young in years," he said, "Professor Baur was an authority in many fields. In remembrance of the time we worked together, of the friendship which united us, I lay down in deep sorrow this wreath of laurel."

Professor Baur has corresponded probably with every man of note in his particular branch of science, and many of them were his personal friends. Their sympathy, expressed in a great many letters, has been no small comfort and consolation to the bereaved family.

The departed belonged to various scientific societies in America; on February 28 of this year the New York Academy of Sciences elected him a corresponding member.

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THE ANIMALS KNOWN TO THE ESKIMOS OF NORTHWESTERN ALASKA.

JOHN MURDOCH.

When the United States government, in 1881, decided to occupy two of the stations proposed by the International Polar Conference, it was my good fortune to be attached to the party which was sent to Point Barrow in northwestern Alaska. During the two years which were spent at the station, we had ample opportunity to become familiar with the zoology of the immediate neighborhood, and as we were near two large Eskimo villages, we were also able to obtain much information as to their habits and way of living. It is of the relation between these Eskimos and the animals of their country that I propose to treat in this article.

Before they came in contact with civilized people these Eskimos were entirely dependent on the animal kingdom for their food and clothing, and indeed for a large part of their weapons and implements; and practically the whole of their existence was spent either in the chase itself, in making ready for the chase, or in preparing the products of the chase for use. These conditions were but little changed at the time of our visit. Except for the almost complete replacement of the bow by the repeating rifle, and a few other less important changes,

we found their habits and customs essentially the same as they were when described by the surgeon of the English ship "Plover," which wintered at Point Barrow during the Franklin search expeditions in the seasons of 1852–54. Since our time, however, numerous parties of white men have lived continuously at the Point, engaged in shore whaling and trading, and of late years there have been missionaries and a school-teacher there, so that, as I am informed, affairs are very different from what we saw then. What I have to say, therefore, must be understood to apply only to the time of my own personal experiences.

The country which these people inhabit forms the extreme northwestern angle of the continent of North America. The permanent winter villages are all on the strip of coast which runs northeast from Kotzebue Sound and terminates in the sandspit of Point Barrow. The shore of the Arctic Ocean east of this point is uninhabited until we reach Herschel Island, in British territory, near the Mackenzie River, though, in their summer wanderings, the people from Point Barrow often went as far east as the Colville River, and sometimes to Herschel Island. On the sandspit at Point Barrow there is a large village, and eleven miles down the coast, at Cape Smyth, another almost as large, near which our station was situated. These two villages formed practically one community. The next village was 70 miles further down the coast, near Point Belcher. The Point Barrow natives had but little to do with this village and practically nothing with the more distant ones. Their knowledge of the interior was confined to a somewhat limited region 75 or 100 miles inland, whither they went in early autumn and late winter to hunt reindeer on the upper waters of the large rivers which empty into the Arctic Ocean east of Point Barrow. The country is a rolling plateau of slight elevation, presenting the general appearance of a country overspread with glacial drift. Small lakes and ponds, which are sometimes connected by inconsiderable streams, abound, becoming more numerous as the land grows lower towards the north. Along the shore line the plateau terminates in steep banks of clay, gravel, and pebbles, looking much like glacial drift, bordered by a narrow steep beach

of pebbles and gravel, and broken at intervals by steep gullies, in which streams run when the snow is melting, and by long narrow and shallow lagoons. These cliffs end at Cape Smyth, where the land becomes low and marshy, and the shore line is continued as a pebbly beach which runs out to form the sand-spit at Point Barrow. Noticeable on this beach are the heaps of gravel which are raised by the ice sometimes 5 to 6 feet in height. Masses of old ice, loaded, as is often the case, with transported material, are pushed up on the beach during severe storms, and melt rapidly in the summer, depositing their load of gravel and stones in heaps. These ice masses are often pushed up out of reach of the waves, so that the heaps of gravel are left thenceforth undisturbed.

Inland the land rises, but very gradually, and the first really broken and hilly ground is decidedly beyond the usual deer-hunting grounds. There are no rocks *in situ* visible in this region, and large boulders are absent. The surface of the ground is covered with a thin soil, which supports a rather sparse vegetation of grass, flowering herbs, creeping willows and mosses, and is thicker on the higher hillsides, forming a layer of turf about a foot thick. Sphagnum abounds in the marshy low-lands. The whole surface of the land is exceedingly wet in summer, except the higher knolls and hillsides. The surface, however, thaws only to a depth of at most 18 inches. Beyond that, the ground is perpetually frozen to an unknown depth.

The climate of this region is thoroughly arctic, the mean annual temperature being 8° F., ranging from 65° to −52° F. The ordinary winter temperature, from December to March, is between −20° and −30° F., rarely rising as high as zero, and still more rarely going beyond it. The worst gales of the year usually occur in January.

The sun is entirely below the horizon for 72 days in winter, beginning November 15, but the midday darkness is never total, even at the winter solstice, as the sun in that latitude is not far below the horizon. Still, the time when one can see to do outdoor work is merely a twilight from 9 A.M. to 3 P.M. Of course for 72 days in summer the sun never sets, and for about a month before and after this time the daylight really lasts all

night. But little snow falls during the winter, and this is so fine and dry that the wind keeps it constantly in motion, forming deep and hard drifts under all the banks, while many exposed places are swept entirely clean. The snow begins to soften and melt about the first week in April, but the ground is not wholly bare before the middle or end of June, while drifts last all summer in some of the gullies. It is on such snow banks that I have seen the patches of "red snow" (*Protococcus nivalis*) looking like claret spilled on the snow.

The sea is usually closed by freezing and the moving in of the pack ice from the middle of October to the end of July. The pack seldom moves far offshore, and there is usually much floating ice all summer. The incoming heavy ice generally grounds on a bar parallel to the shore, and about 1000 yards distant from it, forming a "land floe" of high, broken hummocks, inshore of which the sea freezes over smooth and undisturbed by the pressure of the outside pack, which is usually very rough, consisting of fragments of old and new ice of all sizes thrown together in indescribable confusion. During the early part of the winter this pack is seldom at rest, sometimes moving northeastward with the prevailing current and grinding along the edge of the land floe, sometimes moving off to sea before an offshore wind, leaving "leads" of open water, which in calm weather are immediately covered with new ice (at the rate of 6 inches in 24 hours), and again coming in with greater or less violence against the edge of this new ice, crushing and crumbling it up against the edge of the land floe. The westerly gales of the late winter, however, bring in great quantities of ice, which pressing against the land floe are pushed up into hummocks and grounded firmly in deeper water, thus increasing the breadth of the fixed land floe until the line of separation between this and the moving pack is 4 or 5 or sometimes even 8 miles from shore. The hummocks of this broad land floe show a tendency to arrange themselves in lines parallel to the shore, and if the pressure has not been too great there are often fields of the ice of the season not over 4 feet thick between the ranges of hummocks. After the gales are over, the pack is generally quiet till about the middle of April, when easterly

winds are apt to cause leads to open between the land floe and the pack. These leads now continue to open and shut, varying in size with the direction and force of the wind, until the land floe itself begins to melt and break away, and finally all moves off together. Meanwhile the level shore ice has first "rotted" through in holes, and finally broken up into small floes which join in the final moving off. I have dwelt particularly on these details of the behavior of the ice, because the habits of the marine mammals, and consequently the practices of the Eskimos, are largely governed by the conditions of the ice.

It may be stated as a general principle that it is the presence of the marine mammalia, the seals, walruses, and whales, which enables the Eskimos as a race to maintain their existence in the barren region which they inhabit. Hence, wherever we find Eskimos, we find them making their permanent homes along the seacoast, and leaving the shore only for short expeditions in pursuit of reindeer or musk ox. So far as I know, there is but one instance of an Eskimo community — a relatively small one — which makes its permanent home at any distance from the seacoast, and even these people are obliged to resort to the coast every summer to renew their supplies of oil and other necessary articles. In different regions, different marine animals form the mainstay of the Eskimo's existence. At Point Barrow the animal of primary importance was the smallest of the seals, *Phoca fœtida*, the rough or ringed seal, the Netyik of the Eskimos. Its flesh was the great staple of food, while its blubber supplied fuel for the soapstone lamps which lighted and warmed the winter houses, and its skin served countless useful purposes. Except for the need of some substance of which weapons and other implements could be made, like the ivory of the walrus or the antlers of the reindeer, more or less helped by a supply of driftwood, an Eskimo community would need nothing more than this seal to support existence. It was the only animal which could be taken at Point Barrow in reasonable abundance at all seasons of the year, and a scarcity of seals in winter, due to unfavorable weather, was often the cause of serious hardship, and not seldom of actual famine. Next in importance to the seal was the reindeer. As this animal was

very abundant within the usual range of the Point Barrow Eskimos, they were in the habit of clothing themselves almost exclusively in reindeer skins, which are the most admirable material yet found for cold-weather clothing. Reindeer venison was a highly prized luxury, the antlers furnished material for all sorts of implements, while the long tendons of the back and legs were dried and split up into thread for sewing garments. The only other animals of great importance to these Eskimos were the walrus and whale. Although the latter animal was by no means essential to their existence, nevertheless the capture of several large whales every season added most materially to their comfort, and made them far more prosperous than most of the Eskimo communities with which we are familiar.

Let us now consider the habits of these animals somewhat in detail, taking up first the seals, walrus, and whales, then the bears and other beasts of prey, and next the other land mammals and the birds. The ringed seal was the most abundant of all the seals, in fact the only one which could really be called common, but as they are chiefly to be found in the neighborhood of the ice, they were rarely seen in summer when the sea was clear. When, however, much loose ice was running, seals were always to be found in plenty and many were shot from the umiaks. They were also sometimes captured in stake nets in the shallow bays east of Point Barrow. After the sea began to close they became quite abundant, resorting for air to the open pools amongst the pack. At this season most of the hunters were out every day, carrying a rifle and a small harpoon suitable for throwing, with which they retrieved such seals as they succeeded in shooting. At this season of the year there is considerable danger in going out upon the ice, as a sudden shift of the wind frequently carries out to sea large portions of the still loose pack. The natives used to be very careful not to leave a crack between themselves and the land if the wind, however light, was blowing offshore, but, in spite of their care, men were every now and then carried off and never seen again. At this season of the year, as I have said, a single calm night is sufficient to cover any open water with young ice strong

enough to bear a man. In this young ice the seals make perfectly round holes about the size of a quarter of a dollar, and return to these holes every now and then to take breath. When young ice formed, the hunters used to watch at these breathing holes, standing upon a peculiar little three-legged stool, and using a harpoon with a slender shaft suitable for thrusting through the hole to secure the seal when shot. The fields of young ice last but a few days at a time before they are broken up by the movements of the pack, and the seals do not often have a chance to make regular breathing holes, but depend for fresh air on the irregular crevices among the cracked and splintered ice hummocks. When a hunter discovered such a crevice, he used to set his nets all round it under the ice, and frequently kept them there all winter, visiting them every few days. Many seals were taken in this way. But by far the greatest number of seals was taken in the night netting, which began with the departure of the sun, and could only be carried on successfully on the very darkest nights. The natives told us that even a bright aurora interferes with their success. When a lead of open water appeared, nearly all the men of the village would resort to it with their nets, which they set wherever they found the ice tolerably level and not too thick for about 100 yards back from the lead. These nets are of stout sealskin thong about 15 feet long by 10 deep, and are set under the ice in such a way that they hang down, like a curtain, and can be drawn up through a hole large enough to allow the passage of a seal's body. A number of nets were often set close together. When the night grew dark enough, the hunters would begin to rattle on the ice with their ice picks, whistle, or make some other gentle and continuous noise, which soon excited the curiosity of the seals that were swimming about in the open lead, until they would finally begin to dive under the ice and swim towards the sound, which of course led them directly into the nets. On favorable nights a great many seals were taken in this way. For instance, on the night of Dec. 2, 1882, the netters from the Cape Smyth village alone took at least 100 seals. As at this season the weather is often excessively cold, the dead seals freeze stiff very soon. If sufficient snow had

fallen, the frozen seals were stood up by sticking their hind flippers in the snow to keep them from being covered up and lost if the snow began to drift, and they were left until it was convenient to send out the women for them with dog sledges. I once counted 30 seals, the property of one native, standing up together in a single stack. The night netting comes to an end when the winter gales close the leads permanently. After the sun comes back in the spring there are frequently to be found among the hummocks curious dome-shaped snow houses, about 6 feet in diameter and 2 or 3 feet high, with a smooth round hole in the top and communicating with the water by a large passageway. They look curiously like the work of man, but they are really made by the female seals. In these they bear their pups in the early spring, but after the young have grown large enough to swim about by themselves, they apparently resort to the nearest house when they want to take breath. At all events, the Eskimos used to stretch a net across the opening of one of these houses, when they could find one, under the ice, and often caught a number of seals in succession at the same hole.

In June and July, when the ice becomes rotten and worn into holes, the seals crawl out upon the ice to bask in the sun. At this season of the year they were excessively wary, but were occasionally stalked and shot. The harbor seal (*Phoca vitulina*) was well known to the natives under the name of Kasigia. They said that it was occasionally taken in the stake nets in summer, but was more plentiful near the villages at Point Belcher. To our great surprise, among the seals taken in the night netting in 1881 was a single male of the curious and beautiful ribbon seal (*Histriophoca fasciata*), not previously known to occur north of Bering Strait. It was, however, well known to the natives, although said to be very rare. The great bearded seal (*Erignathus barbatus*), whose skin is specially prized for making harpoon lines, boot soles, boat covers, etc., was never very abundant, and occurred chiefly in the season of open water. Two, however, were taken at breathing holes in the rough ice on Jan. 8, 1883. At the time of our visit, the walrus, which is the species distinguished by Allen as the Pacific

walrus (*Odobænus obesus*), was far from abundant, although they were frequently seen during the season of open and partially open water, swimming about amongst the loose ice or asleep on floating cakes of ice, either alone or in small herds. The natives pursued them in their large skin boats, using a heavy harpoon with a float of inflated sealskin attached to the line, but employing the rifle freely whenever opportunity offered. During the summer of 1883, they had taken about a dozen up to the middle of August.

The polar whale (*Babæra mysiticetus*), the "bowhead" of the whalemen, occurred near Point Barrow only during the spring migrations, when they were traveling northward to their breeding grounds near the mouth of the Mackenzie River. They appeared first as stragglers when the leads began to open about the middle of April, gradually increased in numbers, and continued to pass until about the first of July. Except when the leads were wholly closed, whales were continually passing at this season, even when the leads were full of loose ice. Indeed, the whales seemed to have learned that they were much safer among the ice floes than in the open water, and could often be heard blowing in the loose pack, when there was a broad open channel for them to travel in. On the return migration, which begins about the middle or end of August, they pass by at a long distance from the land. Consequently, the natives pursued them only during the spring migrations. About twenty umiaks, carrying each a crew of eight or ten men, were fitted out at the two villages and dragged on sleds out across the rough ice to the edge of the open water. This whale fishery was the great event of the year, eagerly anticipated and carefully prepared for. It was even invested with a semi-religious character, by a series of elaborate ceremonies and a complicated system of tabus and observances. The umialiks, or owners of umiaks, who were all men of great importance in the village, wore peculiar ornaments, and the crews were carefully selected and regularly hired for the whole season. Whenever there was open water and any prospect of whales, the crews spent the whole time on the ice, while the women traveled backwards and forwards from the village with

their food, and the boats were not brought in till the close of the season. Each boat was supplied with several harpoons, to each of which was attached a short line and a pair of floats made of inflated sealskins, and their plan was to attach so many of these floats to the whale at successive "risings" that he could no longer sink, and they could then paddle up and despatch him. They formerly used stone-headed lances for this purpose. We brought home one, a magnificent piece of flint chipping as big as the palm of my hand, mounted on a shaft 13 feet long. At the time of our visit, however, they were all supplied with regular steel whale lances, and some even had bomb guns.

The dead whale was at once towed to the edge of the solid floe, and all hands — men, women, and children, for the news was never long reaching the village — set to work to cut off all the blubber and meat they could get at. Not seldom the whale sank, or was carried off under the ice, before they succeeded in securing more than a part of the blubber. Every one in the village was entitled to all the meat, blubber, and "blackskin" that he could get, but the whalebone, which had a commercial value, was divided equally among the boats that were in sight when the whale was struck.

The "blackskin," or epidermis of the whale, which is about an inch thick and of a somewhat India-rubber-like consistence, is esteemed a great delicacy, as indeed is the case among all Eskimos who can obtain it. In favorable seasons as many as ten or a dozen whales have been taken, and bones of the whale are plentifully scattered all along the shore and in the village, where jawbones and ribs were used for posts and staging timbers.

Each season of open water, one or two large schools of white whales passed along near the shore, and the Eskimos usually shot a few every year. They were highly prized, not only for their flesh and blubber, but for their skins, which make the best material for waterproof boot soles, and, when plenty, were rarely used to make a very superior quality of harpoon lines. We found that the natives had a good deal of narwhal ivory, easily recognized by its spiral grain, and they informed us that

they occasionally saw the animals. They are, however, very rare, as we saw or heard of none during our stay.

Polar bears were by no means so abundant about Point Barrow as might be expected, and they appeared to confine themselves almost entirely to the ice field at some distance from the shore. Only one of us was lucky enough to see a bear, just making his escape into the moving ice, pursued by all the dogs and half the men and women of the village. The seal hunters shot several bears while we were there, and once or twice during the winter hungry bears came into the village, attracted by the stores of seal meat, and were immediately surrounded and shot. As a rule, however, they were exceedingly anxious to escape when they encountered men or dogs, and we only heard of one or two that showed fight or came to bay. The bears killed in winter were beautifully clean and white, but in summer they grew very dirty and brown. There is a real brown bear, which they sometimes killed inland on the rivers, and they showed us several robes which were the color of the cinnamon bear. It is probably the barren ground bear (*Ursus richardsoni*).

Though the wolf (*Canis lupus griseoalbus*) was well known to the natives, who highly prized the fur for trimming their deerskin garments, it seldom or never appeared on the coast, but was confined to the reindeer country, where, according to the natives, it was very abundant, pursuing the deer in packs.

In the same region they occasionally captured red or black foxes (*Vulpes fulvus fulvus* and *V. f. argentatus*), though most of the skins of these animals in their possession were obtained by trade from the Eskimos whom they met at the Colville River, as were also the skins of the wolverine. The tail of the latter animal is a very important article to the Eskimos of the northwest, for fashion insists that every man shall wear one attached to his girdle behind. If a wolverine's tail is not to be had, the bushy tail of a dog or fox is worn, but it is not considered so fashionable.

Every male must also wear dangling from the back of the jacket, between the shoulders, the skin of an ermine, though this perhaps was more a kind of amulet or *porte-bonheur* than

an ornament. Some, at least, of these ermines are caught near the villages. But of all the fur-bearing animals, the most abundant is the Arctic fox (*Vulpes lagopus*). During the winter the snow was covered with their tracks, which were sometimes noticed far out on the ice, where they had probably been playing the jackal to the bears. They are, however, so exceedingly shy and so well protected by their white coats that they were seldom seen at this season. In summer they were frequently seen quartering the ground like a dog, hunting in search of birds' nests, and, when alarmed, ran with exceeding swiftness, seeming barely to touch the ground. They were, in general, pretty widely scattered over the country, but occasionally congregated in great numbers where carcasses had been washed ashore. If a reindeer were killed that could not be brought in overnight, it had to be carefully covered up with slabs of snow, or the foxes made short work of it. The natives took many of them in winter by building little houses of snow in which they placed a bait, burying a steel trap in the snow at the threshold, or arranging a deadfall so as to be sprung by any animal forcing his way through the narrow entrance. Our trader obtained a large number of white fox skins, mostly in fine condition, with very heavy thick fur. Among them were one or two "blue" skins also in fine winter pelage.

The reindeer of this region is the well-known barren ground caribou (*Rangifer tarandus grœnlandicus*), known to all Eskimos as *tuktu.* This animal did not come down to the coast near Point Barrow in any numbers. Straggling individuals and small herds were occasionally seen during the summer wandering about the plain, and sometimes came down to the beach or took water in the lagoons, especially on calm, sunny days when the flies were troublesome. During the rutting season in the latter part of October, a good many were to be seen roaming about a few miles inland, but they were excessively wild, though the rutting bucks were rather inclined to be curious and came towards a man who kept perfectly still. Later in the winter, from January on, small herds were often seen a few miles from the villages, and we often saw their tracks and the places where they had scraped off the snow to get at the moss.

Two or three hunters were out on snowshoes nearly every day at this season. In the utter absence of anything like cover, stalking was absolutely out of the question, and their practice was to travel straight after the deer as fast as they could. Sometimes the deer would go straight away at such a pace that they would make good their escape, but in most cases their curiosity would get the better of them, and one or more would begin to circle round to get a better view of the pursuer, who would immediately alter his course so as to head them off. As soon as he got within 500 or 600 yards, he would open fire with his Winchester, and keep it up until the deer was killed or driven away. Strange as it may seem, many deer were killed in this fashion. The natives were very lavish of their ammunition, and their reckless shooting had already made the deer very wild. Most of the deer, however, were obtained at the inland hunting grounds already referred to. Many of the natives used to go to these grounds in the autumn, as soon as enough snow had fallen to make sledging practicable, and remained there until the days grew too short for hunting. At this season they found the deer abundant and moving about in large herds. According to their account, the deer left this region and went further inland when the winter night set in, and did not return till about the first of February, when with the return of the sun the great deer-hunting season began. At this season half the village used to resort to the rivers, where they encamped in permanent and comfortably fitted up snow houses, usually in small parties of two or three families each, at some distance from each other. Here they stayed until it was time to return for the whaling, usually about the end of March or the middle of April. The men spent all the available daylight hunting deer, while the women occupied themselves dressing skins and fishing through the ice of the river, usually with excellent success. Heavy loads of frozen meat and fish and rough-dried skins used to be brought in, and the return of the hunters was always celebrated with great feasts, when the pot was kept boiling all day long and every visitor was entertained with venison. The does drop their fawns in the spring somewhere not far eastward of the Point. At this season the Eskimos

were busy with the whale fishery and paid no attention to the deer, but when the fawns were about a month old, small parties used occasionally to go off in quest of fawn skins for making fine garments and trimmings. They told us that they were able to catch the fawns by running them down. In warm weather, when the deer took to the water to escape the flies, they were still chased in kaiaks and killed with a light lance, in the manner so generally practiced by the Eskimos.

These Eskimos had many garments made of the skin of the mountain sheep, and water dippers were very generally made from the horns of this animal, which is the light-colored form known as *Ovis canadensis dalli*. Most of this material was doubtless obtained by trade, but some of our acquaintances had hunted the sheep in high rocky ground, "eastward — far away."

Lemmings, both *Cuniculus torquatus* and *Myodes obensis*, occasionally appear in great abundance. In 1882 we saw none, but the natives began to catch them in January, 1883, and through the season we saw plenty of them. As they spend most of the time in the tunnels which they make in the moss and under the snow, they are seldom seen in winter, except during drifting snowstorms, when the snow over their burrows is probably blown away. The Eskimos believe that at such times they have come down from the sky, whirling round and running about in spirals as soon as they touch the ground. The first one that we obtained was brought in by an Eskimo, who told us, "There are none here on the land. As it was bad weather he fell down from above."

Compared to the mammals, the birds of the region were of little importance to the Eskimos, though they knew and distinguished by name nearly all the species which we found to occur there. During the spring enormous numbers of eider ducks used to pass up the coast, on the way to their breeding grounds in the east, and a few scattering pairs remained to breed. These were mostly of two species, the king eider (*Somateria spectabilis*), which were the first to appear in the migrations and were the most abundant, and the Pacific eider (*S. v-nigra*). Later than the eiders came the great flight of

long-tailed ducks, oldsquaw (*Clangula hyemalis*), flying high, with great clamor, and many of these remained to build about the ponds and little pools. At these pools were also sometimes found the curious spectacled eider (*Arctonetta fischeri*) and the beautiful little Steller's duck (*Eniconetta stelleri*). Three species of geese were also rather plenty and bred. These were *Anser albifrons gambeli*, *Chen hyperboreus*, and *Branta nigricans*, and we rarely saw swans. All through the open season the large burgomaster-like gull, which Mr. Ridgway has described as the Point Barrow gull (*Larus barrovianus*), was very abundant, and the rare and beautiful rosy gull (*Rhodostethia rosea*) appeared in multitudes for a short time each autumn. Less common were the ivory gull (*Gavia alba*) and Sabine's gull (*Xema sabinii*), while round the sandspits lived many Arctic terns (*Sterna paradisea*). All of these birds, especially the larger ones, were used for food, and each had its distinctive Eskimo name. Of less importance were the three species of loons, the few guillemots and skuas, and the many species of wading birds, such as the plovers and sandpipers. Of land birds, the most familiar are the little snow bunting (*Plectrophenax nivalis*), the first bird of the Arctic spring, the little bird who "by and by," said they, "will sit upon a stake and *talk loud*," the Lapland longspur (*Calcarias laponicus*), and two species of grouse, the willow grouse (*Lagopus lagopus*) and the rock ptarmigan (*Lagopus rupestris*), both of which remain all winter, turning white for protection, like the foxes. When the lemmings come, the snowy owls follow them.

As I have already said, the Eskimos paid but little systematic attention to the birds. They shot them when opportunity offered, and the women and children collected all the eggs they could find near their summer camps, but as a general thing the men were too busy to waste time on birds. Towards the end of the summer, however, when they were all gathered at the camp ground, just where the sandspit of Point Barrow leaves the mainland, they really devoted themselves to duck shooting in the intervals of dancing, feasting, and trading with their visitors from the Colville and the sailors from the ships. At this season the ducks are returning in large flocks from the

east, hugging the shore of the mainland, and when they reach the beach, either fly out to sea across a narrow place just above the camp, or else turn and follow the line of ponds which lie just behind the beach. Just at the point where the birds usually turned, the Eskimos had set up a row of posts reaching to the tents. Then on favorable days they concealed themselves in shallow pits dug in the narrow ridge above the camp. When a flock of birds reached the right spot, the gunners would set up a shrill yell. Frightened by this and by the line of posts, for they fly low, nine times out of ten the ducks would falter, become confused, and finally collecting into a compact body, would whirl along the line of posts, past the tents, flying close to the water, and turn out to sea at the first open space, which is just where the gunners are posted.

When the eiders were flying during the spring migration, not a man, woman, or child of either village ever stirred outdoors without at least one set of bird bolas. This weapon, with its six ivory balls, they used with considerable skill, though I have often seen it thrown at foolishly long range. It is a curious sight to see a duck settle down out of a flock, as the twisting cords wind themselves round his wings.

We have now enumerated all of the most important mammals and birds with which these Eskimos were acquainted, and have pointed out the different ways in which they were in the habit of making use of them. Much that would be interesting might be said about the fishes of the region, as well as what the Eskimos told us of what they thought about the lower animals, but space will not permit.

METHODS IN PLANKTOLOGY.[1]

GEORGE WILTON FIELD.

HUMAN existence is dependent upon the oceanic fauna and flora far more than is generally suspected. Scientific investigation has demonstrated a most remarkable biological chain and has elucidated the links which connect the lowliest of the microscopic plants with the most highly developed mammals. In the continual cycle of matter from inorganic to organic, from organic to inorganic, with the attendant alternate storing up and liberation of energy, are to be found the secrets at the basis of life. It is commonly held by biologists that life originated in the sea ; and it is in the sea to-day that we find those plants and animals which have departed least from the original, the ancestral condition, in which life is not complicated by diversity of form or function.

Some of the work carried on by the biological department of the Rhode Island Experiment Station has been upon the Methods of Studying the Œcology of Marine Organisms, since a knowledge of the marine organism is of immense importance in understanding the questions connected with the fundamental food supply on the earth.

The number and variety of the animal and vegetable population of the ocean are well-nigh infinite. Any two regions more or less remote from each other show differences in their oceanic fauna and flora, generally proportional to the distance either horizontal or vertical which separates them. The fauna and flora of the tropical Caribbean Sea differs widely from that of the Arctic oceans ; that of the water south of Cape Cod differs markedly from that north of the Cape, though separated only by a very few miles of land. The organisms characteristic of the surface in any region are wonderfully different from those of the abyssal depths. Yet even in the same locality remarkable

[1] Reprinted from the *Annual Report of the R. I. Agricultural Experiment Station*, 1897.

variations are the rule. These variations are conditioned not only by temperature, specific gravity, atmospheric pressure, and light, but probably by fundamental phenomena of which science as yet knows nothing. Certain forms spend the day in the depths, appearing at the surface only at night ; for various forms the reverse is true. There are other temporal differences, — yearly, monthly, daily, and hourly variations, — whose causes are manifold, in part climatic or meteorological, in part depending upon the conditions of life, of reproduction, and development. Still other variations are brought about by the numberless currents great and small, which not only collect the organisms into eddies and scatter the "schools," but transport organisms characteristic of one region to places far remote from their home, *e.g.*, the Gulf Stream carries tropical forms far into the cold northern seas.

All the organisms which are borne about helplessly by currents, or whose motions are determined by protoplasmic activities (heliotropism, chemiotropism, etc.), as distinguished from special and effective locomotory organs, constitute the Plankton (a word coined by Professor Hensen from the Greek *πλανᾶσθαι*, to wander). The Plankton has attracted naturalists since the studies of Johannes Müller, but Professor Hensen was the first to give earnest attention to the economic importance of the Plankton, and to the problems of the food supply based upon it. He was led to this through his attempt to get an approximate idea of the number of fish in corresponding districts. This work brought him to the question of the food supply for these fishes, and from that to consideration of the general primary sources of food and the cycle of matter in the ocean. This has led to important results in tracing the cycle of changes through which the organic elements, carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, iron, and others pass; in showing how they either singly, or united in simple combinations, become incorporated into a living (it may be microscopic) plant ; how this plant is eaten by a mollusc or a small fish, a prey in turn for larger and fiercer fish, which ultimately die and are broken up by microscopic plants (bacteria) into the original elements, to again nourish plants. The actual cycle is rarely so simple as

described above. Complicating conditions usually appear at every stage. Naturalists are gradually unraveling these complications. But the point which is of special importance is that very many of these marine animals may furnish economical, healthful, and delicious food for man. That this may be a never-failing source of food supply for an increasing human population, not only must the habits, haunts, and life histories of such food animals (fishes, molluscs, crustacea, etc.) be elucidated, but also their relation to natural phenomena, meteorological conditions, currents, etc., and especially to the Plankton, upon which they depend more or less immediately for food. This necessitates study of the Plankton as the basis of food supply for our most important marine food animals.

The study of the economic aspects of the Plankton and the application of the results to cultivation of water areas have demonstrated that the water responds even more bountifully than land areas to cultivation. It is an interesting economic fact that less than 15 cubic feet of cultivated water is sufficient to support at least the head of a family (and probably a considerable number of other dependents) of Italians in Tarente, while 6 cubic feet do the same in Japan. Numerous experiments demonstrate that the yield of cultivated water area surpasses in essential food elements that of equal area of cultivated land. Herein lies the great importance of a knowledge of the Plankton, the basis of marine life. The Plankton also enters as an important and, in certain aspects, as an undesirable element into the question of municipal water supplies, and the necessity of healthful and palatable drinking water has stimulated not a little the study of the quantitative and qualitative constitution of the Plankton.

Since the time (1884) when Hensen entered upon his work of counting laboriously the number of organisms in known quantities of sea water, for the purpose of ascertaining the amount of living matter which exists in given volumes of water, and thus furnishing a basis for scientific aquaculture, much attention has been given to the methods of Planktology and rapid progress has been made. The great desideratum even now is a rapid, simple method by which data can be

obtained which can be used for comparison of all waters. Not until the invention of such a method can accurate and valuable comparisons be made.

At the basis lies the method of collecting the organisms from an accurately determined quantity of water. An ideal method is one which includes the concentration of the organic matter in a known quantity of water into a smaller known quantity of water, which quantity should be a convenient multiple of the original quantity. In the process not even the smallest of the bacteria should be lost. Counting and enumeration of individuals and species is necessary, together with an estimation as accurate as possible of the volume of the water, of the inorganic matter, and of the organic amorphous débris (plant and animal). The counting can best be done by the Sedgwick-Rafter method (Rafter, G. W., '92). By this method a fairly accurate idea can be formed of the comparative volumetric and numerical proportions between the three main elements involved in the biological study of water; *viz.*, the living organisms, organic amorphous débris, and inorganic substances (silt, gases, and substances in solution). It would seem that the necessary data must be based ultimately upon the counting method until such time as means can be devised for separating the living organic from the dead (both organic and inorganic) substance, and for determining the amount of each. In considering the quantity of living organisms not only the number but also the size of the individuals must be taken into account. Professor Hensen introduced the counting methods for the purpose of determining the economic yield of the ocean in the same way as the farmer determines the useful yield of his fields and meadows, the annual production of grass and grain. Professor Haeckel in stating his objections to this method said: "The farmer determines the yield of his meadows, garden, and field by quantity and weight, not by counting the individuals. If instead of this he wished to introduce Hensen's new exact method of determination, he must count all the potatoes, kernels of grain, grapes, cherries, etc., not only that but he must also count the blades of grass in his plot, even every individual weed which grows among the grain of his field and the

useful plants of his garden, for these also, regarded from the physiological point of view, belong to the 'total production' of the ground." (Translation in Report of U. S. Commissioner of Fish and Fisheries for 1889–91, pp. 565–641, of *Plankton Studien, Jenaische Zeitschrift,* Bd. xxv, 1890.) It would seem as if Professor Haeckel overlooked the fact that the farmer can readily separate the hay, etc., from stones, dead sticks, and other foreign material. He can accurately determine the volume and weight of farm products. He does not have to contend in this connection with foreign substances, such as silt, organic débris, etc., which render inaccurate determinations by weight and volume of the contents of water from ponds, lakes, and oceans. It is these elements which thus far have prevented any apparent progress in establishing tables of the economic yield of water volumes on the basis of weight, volume, and number of individuals, which would be of value for comparison in determining the commercial importance of any area or any depth of water.

It is, too, the presence of an undetermined and locally varying quantity of organic débris which renders inaccurate the estimation of the economic value of water by means of the determination of the albuminoid ammonia.

Numerous methods of Plankton collecting have been devised; the most important of these may be grouped as follows:

(1) By drawing a fine net through known volumes of water.

(2) By passing known volumes of water through a filter of either (*a*) fine silk bolting cloth, or (*b*) fine sand, or (*c*) a combination of *a* and *b*.

(1) The net and the method of using it have been subjected to much study by Hensen (**'87** and **'95**), Apstein (**'91**, **'92**, and **'96**), Reighard (**'94**), Ward (**'96** and **'96a**), Borgert (**'96**), Kofoid (**'97**), and others. From the net method it seems impossible to exclude several prolific sources of uncertainty in the results; *viz.*, (*a*) it is impossible to be *certain* of the quantity of water through which the net is drawn, and consequently of the quantity which passes through the net even in motionless water; (*b*) currents in the water almost hopelessly complicate the conditions; (*c*) the progressive clogging of the net cannot be

avoided; (*d*) there is an actual loss of small individuals through the meshes of the net; (*e*) the long and complicated process must necessarily give varied results due to personal variations in methods of work, and to changes in the local conditions, *e.g.*, the rate of currents may vary from day to day, the quantity of silt may modify the filtering capacity of the net, etc. Any one of these sources of error is sufficient to invalidate the entire method, rendering the results worthless for comparison with the results of similar processes in different localities.

Under (2) (passing known quantities of water through a filter of fine bolting cloth) the sources of error are reduced but not eliminated; (*a*) the pressure of water forces certain small forms, *e.g.*, certain species of bacteria, through the meshes. Many of the very delicate forms may be broken up and destroyed; (*b*) failure to wash out all the individuals from the net. The method of pumping known volumes employed by Kofoid ('97) is particularly good. The most apparent source of error is the control of the quantity of water pumped, and the possibility that the strong suction of the pump used may draw mud when the water is taken within a foot of the bottom. In the method of filtration through sand, as employed by Calkins ('91) and as improved by Jackson ('96) and by Whipple ('96), the possible sources of error are several, varying with the characteristics of the sand used, with the shape of the funnel, and with the nature of the organic matter in the water. Calkins says: "The sloping sides of the glass funnel offer a surface for the settling of organisms, and the error arising in this way may be considerable. A water free from amorphous matter and zoogloea will filter very accurately, but a water containing these gives opportunity for error." Jackson ('96) adds: "This is undoubtedly due to the jelly-like character of the zoogloea, and to the fact that while adhering to the funnel sides itself, it also retains with it other organisms." . . . "Not only do amorphous matter and zoogloea readily adhere to the sides of the ordinary glass filter funnel, but the same is true of the gelatinous growths of the Cyanophyceæ and of the flocculent threads of Crenothrix." Even Jackson's ('96) improvements in the sand filtration method which reduce to a minimum

the liability of error cannot remove the defects inherent in the process itself. The defects noted by Whipple ('96) are involved in the method of concentrating the sample, *viz.*—(1) the funnel error, arising from the adherence of organisms and amorphous débris to the sides of the funnel; (2) the sand error, caused by organisms passing through the sand; (3) the decantation error, resulting from the adhesion of organic matter to the particles of sand, and from the capillary retention in the sand of the water used in washing the sand during decantation; to the above should be added (4) the destruction of the very delicate organisms by the sand in the process of decantation. The practical value of the method for comparative results in the hands of different workers is invalidated by the multiplicity of conditions affecting the results; among these are the nature and amount of the sand, the care and skill of the worker, and particularly the nature of the sample to be filtered.

Kofoid (*Science*, vi, 153, Dec. 3, 1897, "On Some Important Sources of Error in the Plankton Method") found that filter paper (No. 575 Schleicher & Schüll) was more effective than the sand filtration method, giving 75% to 85% of the planktonts as compared with 40% to 65% given by the sand filters. Kofoid has detected the advantage of filtration through very delicate porous media, and finds that fine infusorial earth is very efficient, and in spite of minor difficulties connected with the final separation of the planktonts from the infusorial earth he regards this as the most satisfactory method thus far devised. I might add that the total weight of material (organisms, organic and inorganic débris) suspended in water is of fundamental importance and can be determined with considerable accuracy by this method, though I see no way to ascertain the relative proportion of organisms and débris except very roughly through the enumeration of the individual organisms and comparison of the apparent bulk of the masses of living and dead material as seen under the microscope.

Experiments have been made by adding various quantities of either corrosive sublimate, picric acid, acetic, and other acids, alcohol, and formalin to known quantities of water, with a subsequent determination of the volume and constituent elements

of the precipitate. The space required, the tediousness, the loss of organisms, the fact that in this new process very many forms break up before all the material is settled have led to its abandonment in favor of the employment of centrifugal force. Previous to 1896 Cori devised a simple hand centrifuge and used it for collecting infusoria for class work. Last year a brief reference was made to our work with the centrifugal

The Planktonokrit.

method (Field, '97, I). Since then Kofoid ('97) has experimented on similar lines. His machine is "geared to give 3000 to 4000 revolutions per minute and arranged to act upon a continuous stream of water, all of which was subjected to the maximum and uniform action of the centrifugal force." This machine secured in some instances 98% of the planktonts. But as I pointed out last year, it is not so efficient with those organisms whose specific gravity is about that of water, such as the Cyanophyceæ, Anabœna, Clathrocystis, *et al.*

Experiments have been made with the centrifugal machine devised by Dr. C. S. Dolley, called the Planktonokrit, and

described by him (Dolley, '96) : "An apparatus which consists of a series of geared wheels driven by hand or belt, and so arranged as to cause an upright shaft to revolve to a speed of 8000 revolutions per minute, corresponding to 50 revolutions per minute of the crank or pulley wheel. To this upright shaft is fastened an attachment by means of which two funnel-shaped receptacles of one liter capacity each, may be secured and made to revolve with the shaft. The main portion of each of these receptacles is constructed of spun copper, tinned. To this is attached the stem of the funnel, consisting of a heavy annealed glass tube of 15 mm. in outside diameter with a central bore of 2½ to 5 mm. These glasses are held in place and protected by a cover, such as is employed in mounting a water gauge.

"The receptacle having been filled with the water to be examined, is caused to revolve for one or two minutes, when the entire contents of suspended matter in the water is thrown down to the bottom of the tube, from which the volume may be read off by means of the graduated scale on the outside of the tube. The plankton thus expeditiously secured can be transferred quickly to a vial or other receptacle, to be weighed or otherwise examined at leisure."

Power may be applied either by hand or through a belt by steam or electric motor.

Our experience with the Planktonokrit indicates :

(1) That two men on each crank cannot get a speed at the receptacle above 3000 revolutions per minute; a rate, however, sufficient to throw out everything except the Cyanophyceæ.

(2) The maximum speed must be continued for at least four minutes.

(3) A speed much above 4000 revolutions with such a large quantity of water is dangerous, with the machine constructed as at present.

This danger may be obviated:

(*a*) By reducing the capacity of the receptacle. (500 cc. is probably sufficient.)

(*b*) By lengthening the bearings of the upright spindle.

(c) By enclosing the revolving receptacles in a circular chamber, thus lessening the resistance of the air.

(4) When power was used, more satisfactory results were obtained by arranging the driving pulley so as to cut out the two largest sets of gears. Friction was thereby greatly reduced, and the necessary speed was gained from more rapid revolution of the driving pulley.

(5) It is probable that four receptacles would work more satisfactorily than two.

Some difficulty was experienced in avoiding leaks at the ends of the glass tube. At the distal end the insertion of a closely fitting, vaselined rubber "mushroom" (such as is used when repairing punctures in bicycle tires) was found to answer. Care had to be exercised to keep the entrance to the tube free at the proximal end. To obviate this difficulty it is hoped that a small, heavy annealed glass cone with a ground glass stopper at the apex can be devised in place of the tube.

That the centrifugal method is beyond question the best method of collecting the substances suspended in the water for accurate determination seems to be proved, and great credit is due to Dr. Dolley for his demonstration of the fact.

This method is of value, not alone to him who wishes to determine the proportions of organic matter in drinking water, and to ascertain the quantity of microscopic plants and animals in water from special localities (a very accurate index of its commercial value for fish and shellfish cultivation), but it will enable biologists to study more successfully those lowly forms which lie close to the basis of life, the delicacy of whose structure precludes handling by nets or filters.

It is believed that the perfecting of the centrifugal method for collecting the Plankton will greatly facilitate the practical solution of the increasingly important question of the food supply for man, by ameliorating some of the difficulties which surround the rearing of edible fish in confinement. The eggs can be hatched by millions, but difficulty arises in obtaining a natural or proper food supply. Hence in the case of most species the fry must be liberated very soon after hatching. But every additional day in which they can be kept in confine-

ment increases in a remarkably large ratio the number of these young fish which attain maturity, for the reason that the very young fry are specially liable to destruction from rapacious enemies, storms, etc. With the use of the centrifugal machines for collecting the microscopic food for the young fry, they can be kept longer in confinement, and probably the advantage may be twofold, for in addition to diminishing the mortality, we should expect that growth would be accelerated under the influence of abundant food.

The Rhode Island Agricultural Experiment Station maintains a card catalogue of works upon the subjects connected with Investigations on the Plankton. Printed copies of the Bibliography will be sent upon application. Workers are requested to forward reprints of their papers. Address Biological Division, R. I. Experiment Station, Kingston, R. I.

SOME NEW POINTS IN DINICHTHYID OSTEOLOGY.

C. R. EASTMAN.

THE standard of comparison for all Arthrodiran fishes is the typical genus Coccosteus Agassiz, the osteology of which is known in the minutest detail. As our knowledge of allied genera increases, the more closely do we find them connected by intermediate stages, and the better are we able to trace the sequence of modifications passed through by them. The group of Dinichthyids (*Dinichthyinæ*) is a large one, and contains many bizarre forms, most of which are still very imperfectly known. But when their characters shall have been fully investigated, the wide range of variation manifested by them will be found reducible to order, and the whole promises to constitute one of the most interesting evolutionary series known among fossil fishes.

The characters of Dinichthys have been made out very gradually, through slow, persistent effort, but we are still far from having a complete knowledge of any one species. The only one in which the cranial osteology has been worked out with tolerable accuracy is *D. intermedius*, although the heads of *D. terrelli* and several smaller forms are not uncommon and are not always ill-preserved. Tardiness in acquiring information was inevitable, however, in the case of the Ohio Dinichthyids, owing to their prevailing mode of occurrence in concretions, with attendant obliteration of details. The supply from other localities has been meager, and is preserved in widely scattered institutions. Even where the Ohio material has been concentrated in some of our leading museums, facilities for investigating it have often been lacking. Under such conditions progress has necessarily been slow.

Reference was made in the August number of this journal (p. 556) to the discovery of several well-preserved crania of *Dinichthys pustulosus* from the Hamilton Limestone, which

prove this species to be the most primitive member of the genus known. It is now proposed to illustrate its osteology more fully, and at the same time offer comparisons with other Arthrodires, including Coccosteus and Titanichthys. The two last-named genera, in fact, may be taken to represent the extreme limits of the family *Coccosteidæ*. For in whatever grouping Dinichthys be placed, be it of subfamily rank or otherwise, there is no question that Titanichthys should accompany it; and the relations of Dinichthys to Coccosteus are seen to be so intimate, we are unable to remove it from the same family. On the other hand, the separation of Macropetalichthys and some other Arthrodires from the *Coccosteidæ*, where they are now commonly placed, seems advisable.

Dinichthys pustulosus.

Besides the examples of this species preserved in the Museum of Comparative Zoology, of which the most perfect cranium is from Rock Island, the writer has been able to consult a number of fine specimens belonging to Messrs. Teller, Monroe, and Slocum, of Milwaukee, two from the Cedar Valley Limestone belonging to the State University of Iowa, and one belonging to the United States National Museum, of which last an illustration is given herewith (Fig. 1). The original of this was kindly loaned by Mr. F. A. Lucas, curator in charge of comparative anatomy; the Iowa material by Prof. Samuel Calvin; and the Milwaukee specimens by their owners, to all of whom grateful acknowledgments are hereby rendered.

The larger and more specialized species of Dinichthys and Titanichthys have a nearly flat cranium, and the surface of all the derm plates is smooth, these probably having been covered in life by the integument. The cranium of *D. pustulosus*, on the other hand, is strongly arched from side to side, and, like all the body plates, is covered with innumerable small rounded tubercles, slightly stellate at the base. A narrow band along the sutures, however, is generally striated and destitute of tubercles; and the suture lines themselves are undulatory. In all of these particulars the species bears a

great resemblance to Coccosteus, yet even more striking is the similarity in pattern of the head bones and arrangement of the sensory canals. The transitional characters are so appar-

FIG. 1. — *Dinichthys pustulosus* Eastm. Hamilton Limestone, Milwaukee, Wisconsin. Fragment showing sutures, sensory canals, and finely tuberculated ornament of cranium. Original in U. S. National Museum (Cat. No. 19). Direction of longitudinal axis indicated by the arrow, lettering as in Fig. 2. $\times \frac{2}{3}$.

ent as to preclude the idea of assigning the two genera to separate families.

An attempt is made in Fig. 2 to represent the cranial shield of *D. pustulosus* as if flattened out, thus facilitating a compari-

son with other diagrams. It is intended at some future time to reproduce a large scale photograph of the Rock Island cranium, on which most of the sutures and sensory canals are visible, in order to show the appearance in perspective of a form so highly arched from side to side as this. The most noteworthy feature regarding the sutures in this species is their prevailing undulatory outlines. No other Dinichthyid has them so sinuous, and even those of Coccosteus are less so in some regions. Beginning with the median occipital element (*MO*), we observe that it is longer and less tapering than in other species of Dinichthys, and is of about the same relative proportions as in Coccosteus. But instead of being slightly sulcated anteriorly, as in *C. canadensis* and some other species, it is deeply lobed, and the anterior boundary is decidedly wavy. Immediately in front of the median and external occipitals lie the paired central elements (*C*), which exhibit almost identical relations with those of Coccosteus. Their anterior and lateral margins are more wavy than in Coccosteus, but their common longitudinal suture is less so. In advance of the centrals are the large preorbital plates (*PrO*), which are separated in front by presumably two median elements, the pineal (*P*) and rostral (*R*). It was impossible, however, to determine the relations of these two plates from any of the specimens that came under the writer's observation, beyond that the pineal seems to be very narrow and without visible perforation. Likewise the boundary between pre- and postorbital plates is indistinct throughout the greater portion of its length ; but it is believed that all of the remaining sutures are accurately delineated in the figure.

One of the most marked points of similarity between *D. pustulosus* and Coccosteus is the fact that the central elements (*C*) are in contact with one another mesially throughout their entire length. These plates are similarly united in Phlyctænaspis, Brachydirus, Homosteus, and Titanichthys, which are sufficient to establish it as a general rule throughout the family *Coccosteidæ*. But an exception would appear to be furnished by *D. intermedius* and *D. terrelli*, provided we can depend upon the descriptions of earlier writers as trustworthy. The

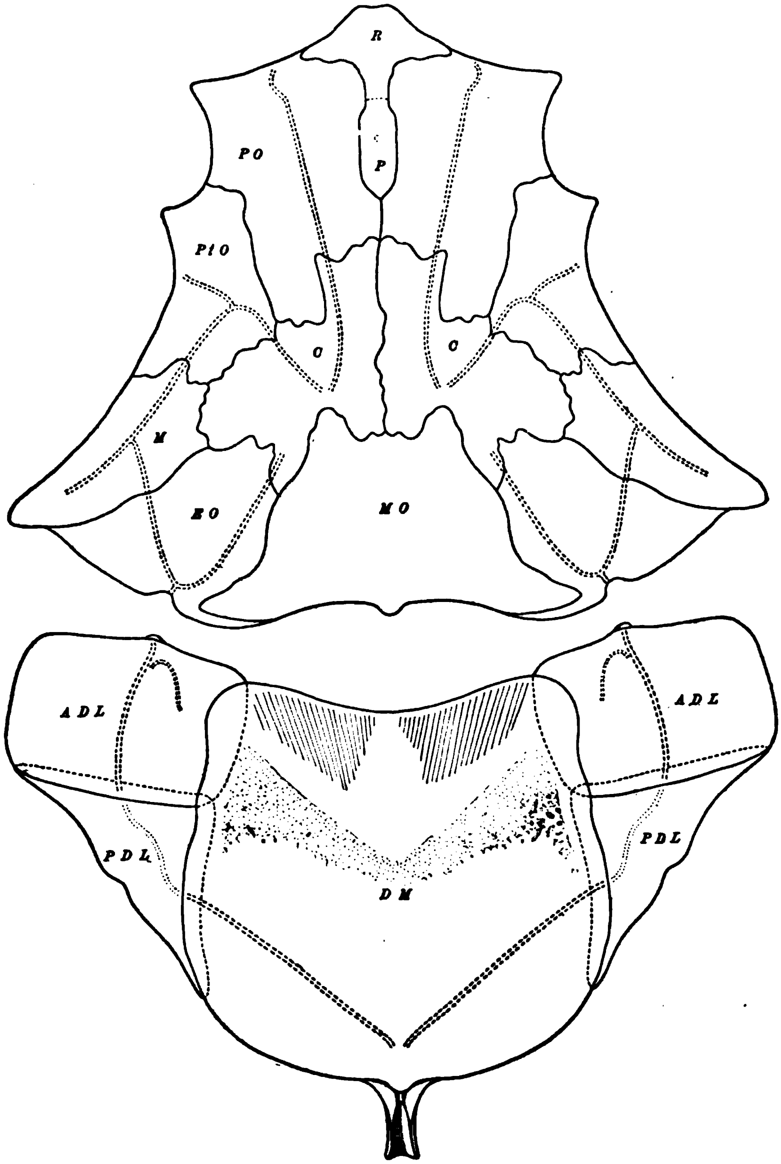


FIG. 2. — *Dinichthys pustulosus* Eastm. Hamilton Limestone, Wisconsin. Diagram showing cranial and dorsal shields. × ½. *Abbreviations: ADL*, antero-dorso-lateral; *C*, central; *DL*, dorso-lateral; *DM*, dorso-median; *EO*, external occipital; *M*, marginal; *MO*, median occipital; *P*, pineal; *PDL*, postero-dorso-lateral; *PO*, preorbital; *PtO*, postorbital; *R*, rostral.

restorations of the cranial shield in these species, as given by Newberry, Claypole, and Dean, all show a subdivision of the space corresponding to the centrals in Coccosteus into two paired plates, which are designated as "parietals" and "frontals." Claypole,[1] in describing the skull of *D. intermedius*, speaks as follows regarding the frontal plates: "This area is well outlined in Dr. Newberry's figures, where its boundaries are much more clearly marked than in the specimen now described." And again, in regard to the "parietals" he says: "Judging from the conventional form which he has given to this plate in his restoration, its outlines cannot have been clearly defined in the specimen which Dr. Newberry studied. Instead of the small and elliptical area which he has assigned to it, it has a large size and an irregular outline." We see from this that Newberry's specimen (or specimens) failed to show perfectly the boundaries of one of the subdivisions of the central plate, and Claypole's failed to show the other. It is fair to allow that appearances may have been suggestive of a division in some examples; but the writer can only state from his personal experience that he has not yet been able to observe such a division of the centrals in *D. intermedius* and *D. terrelli*, and is positive that none exists in *D. pustulosus*. We will revert to this matter again under the head of the first-named species.

The arrangement of sensory canals in *D. pustulosus* is very much the same as in other species of this genus, except that they are more curved, especially the preorbital canal, thus recalling the conditions in Coccosteus. In the latter genus, but not in Dinichthys, a lyra is formed in the middle of the shield by the disposition of sensory canals on the central elements. That is to say, the canals following the boundary of the median occipital bend around towards each other, and a transverse channel connects the point of origin of the pre- and postorbital canal systems. A survival of this lyrate arrangement exists in *D. pustulosus*, in that occasionally one or more short, slightly curved, independent canals are seen to

[1] Claypole, E. W. The Head of Dinichthys, *Amer. Geol.*, vol. x (1892), pp. 199–207.

originate below the middle of the central plates and sweep inwards and downwards not far in advance of the median occipital element, sometimes even traversing it for a short distance (Fig. 1). Similar isolated canals occupy the same position in the crania of Titanichthys (Fig. 4), and very often a reminiscence of them appears in *D. terrelli.*

The canals traversing the external occipitals form a Y, whose descending branch passes across the articulating condyle of the antero-dorso-lateral, and thus emerges upon the dorsal system of body plates. In Coccosteus the canal traversing the antero-dorso-lateral bifurcates as soon as it crosses the condyle, a branch running toward either of the posterior angles of the plate, and that running toward the postero-internal angle is continued upon the dorso-median plate. In Dinichthys and Titanichthys there is no such bifurcation on the antero-dorso-lateral, but the canal is single, extending backward along approximately the middle of the plate, and thence on to the postero-dorso-lateral. Nevertheless, in *D. pustulosus* a reversion toward Coccostean conditions is occasionally met with, inasmuch as the antero-dorso-lateral may have a second short canal, ending blindly, as shown in Fig. 2.

None of the American Dinichthyids have heretofore been known to have the dorso-median traversed by sensory canals, although this condition exists in a small European species, described as *D. pelmensis.*[1] But the dorso-median of *D. pustulosus* bears distinct traces of canals, albeit the grooves are narrower and shallower than those of the antero-dorso-lateral plate. They extend obliquely backward from the point where they leave the postero-dorso-lateral and terminate just before reaching the median line of the shield. Only one example of the postero-dorso-lateral has thus far been encountered,[2] and as it lies with its external surface embedded in the matrix, the course of the canal system across this plate (indicated on the diagram by dots instead of dashes) has yet to be verified. Plates that are evenly embedded like this are likely to have

[1] *Bull. Mus. Zool.*, vol. xxxi (1897), Pl. II, Fig. 4.

[2] Now deposited in the Milwaukee Public Museum with the rest of Mr. C. E. Monroe's private collection, of which it forms a part.

their thin edges preserved entire, thus showing the full extent of the overlapped area. We know this condition very well for the element in question, but the same cannot be said for the antero-dorso-lateral, whose thin overlapped edges are invariably broken away in all species. Accordingly, we have had to follow only the broken margin in drawing the outlines of this plate in Figs. 2 and 3, although without doubt the area overlapped by the dorso-median on the one side and clavicular on the other was much greater. The union of the dorso-lateral plates in this species is one of simple overlap, and not by pegs and sockets, as in *D. terrelli* and *D. intermedius.* Here again the resemblance is with Coccosteus.

Through an oversight, the markings on the antero-dorso-lateral, where the overlapping clavicular came in contact with it, were omitted from the diagram, but are essentially as shown in Fig. 3. One example of the clavicular was obtained by Mr. Teller near Milwaukee. It is an extremely heavy plate, bifurcated anteriorly as in other species and tuberculated on its external surface.

Another point of resemblance to Coccosteus is observed in the slight anterior emargination of the dorso-median. The exposed area between this plate and the occiput was very small in comparison with other Dinichthyids. As shown in Fig. 2, the forward part of the dorso-median is quite destitute of tubercles, and the demarcation of the barren area takes place along an oblique line extending from the middle of the shield toward either of the antero-external angles. This we regard as indicative that the anterior portion of the plate was buried beneath the integument. The median keel on the inferior surface is well developed and terminates in a massive posterior process, which attains a length of over 12 cm. in the adult. It depends at a greater angle with the shield than in the larger species, being in fact almost vertical. In this respect it agrees with other primitive tuberculated forms, such as *D. livonicus, D. trautscholdi, D. pelmensis,* and presumably also *D. ringuebergi.* The average length of the shield in the median line, exclusive of process, is about 21 cm. in the adult, and maximum width about 36 cm.

Dinichthys intermedius Newberry.

Fig. 3 shows the arrangement of cranial and dorsal shields in this species, as determined from specimens in the Museum of Comparative Zoology. The diagram of the head is based on a cranium that has already been described with considerable detail by Claypole,[1] and his figure was copied with slight modifications in a former paper by the writer.[2] The present figure does not differ materially from either of the preceding ones, except that the boundaries of a few plates are slightly altered, the position of the pineal foramen is indicated, and the suborbital and opercular ("postmaxillary" Newberry), which do not properly form a part of the head shield, are here omitted. A supernumerary sensory canal, thought by Claypole to extend along the boundary between the pre- and postorbital plates near the orbits is also suppressed, as nothing but the suture was observed in this region. The pineal plate has been shortened somewhat, but its outline is still conventionalized after Claypole's figure, the element itself being missing from the specimen. In *D. terrelli* and *D. pustulosus* this plate is relatively shorter and narrower than here represented, but owing to its tenuity, is seldom well preserved.

As already remarked, the writer has not been able personally to observe a division of the central element into two plates, termed by Newberry, Claypole, and others the "parietal" and "frontal." The boundary, as depicted by Claypole, has been allowed to stand in dotted lines on the present figure, but the two portions occupying the space of the central are designated C^1 and C^2, instead of by the misleading terms commonly applied to them. If two plates could actually be shown to exist here, the terms *central* and *precentral* would be decidedly more fitting. It is true that in Phlyctænaspis a division of the marginal into two separate elements, angular and marginal proper, has been noticed by Traquair;[3] and unless von Koenen[4] has mistaken the initial portion of the preorbital canal for a suture, a similar

[1] *Loc. cit.* (1892), pp. 199–207.

[2] *Bull. Mus. Comp. Zool.*, vol. xxxi (1897), Pl. I, Fig. 1.

[3] *Ann. Mag. Nat. Hist.* [6], vol. xiv (1894), p. 369.

[4] *Abhandl. Akad. Wissensch. Göttingen*, Bd. xl (1895), Taf. II, Fig. 6.

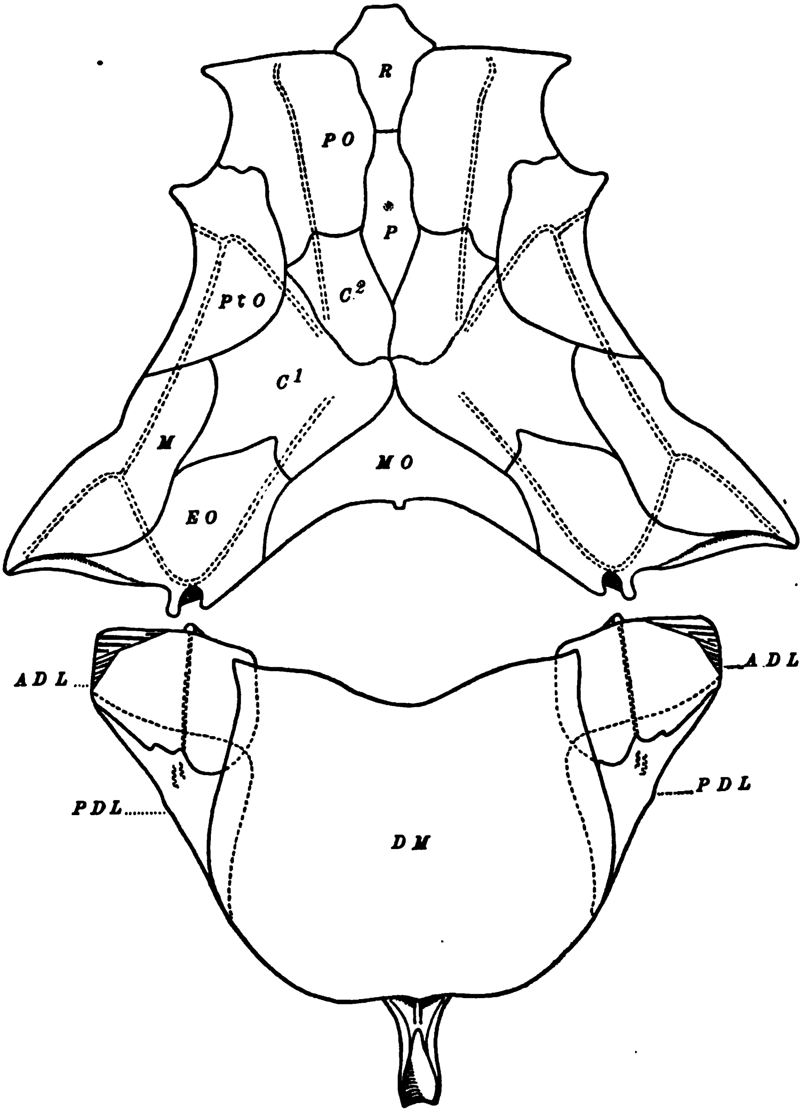


FIG. 3. — *Dinichthys intermedius* Newb. Cleveland Shale, Lorain County, Ohio. Diagram showing cranial and dorsal shields. × ½. Lettering as in Fig. 2.

division of the central element of Brachydirus into two plates is to be inferred. But owing to the poorly preserved condition of von Koenen's material, a confusion of sensory canals and sutures was easily possible; and a comparison of the remaining

figures, given by this author, leads us to believe that the central was in reality undivided in Brachydirus; that is to say, its relations are the same as in Coccosteus and *D. pustulosus*.

There is a chance, therefore, that the recognition of a precentral plate in Dinichthys depends upon faulty observation, and we are strongly of the opinion that no *bona-fide* sutures were ever seen on the dorsal surface cutting off a portion of the central, as earlier writers would have us believe. But on examining the visceral surface of the head shield, one can easily understand how the solidifying crescentic ridge (seen one on either side of the median line and abutting against the equally heavy ridge of the median occipital), which stands in marked contrast to the thin forward extension of the central, might give one the impression of a distinct element.[1] The function of these ridges is to strengthen the base of the skull, and it would be strange, indeed, if they were cut through by sutures visible from below, where such are generally more obliterated than on the dorsal surface, and yet are not apparent from above. It is true that the ridges rise very abruptly, but although their separation from the central plate proper may seem to be indicated by some specimens, owing to difference in texture of bone substance, we regard it as very improbable that a suture exists here. Inasmuch as the central is a single element in *D. pustulosus*, it would certainly be anomalous not to find it entire in all species of this genus.

The median occipital element of *D. intermedius* is acutely pointed in front, with the apex extending forward between the centrals, as in Phlyctænaspis and Brachydirus, but this is an exception to the general rule in Dinichthys and Titanichthys. The anterior margin of the median occipital in *D. terrelli* resembles that of *D. pustulosus*, except that the indentations are shallower. Both *D. intermedius* and *D. terrelli* have the nuchal margin strengthened below by a heavy ridge which extends from the median line obliquely outward and backward on either side as far as the sockets of the exoccipital plates. In *D. pustulosus* the ridges on the under surface of the occipital

[1] *Cf.* Newberry, J. S. Palæozoic Fishes of North America, *Monogr. U. S. Geol. Surv.*, vol. xvi (1889), Pl. LII, Fig. 1.

and central elements are not nearly so heavy as in other species of Dinichthys, and the formation of the double socket in the middle of the nuchal line is simpler. This peculiar structure is supposed by Claypole to mark "the place of insertion of some powerful muscle or ligament that connected the head with the rest of the body." It is well shown in a number of Newberry's figures of Dinichthys and Titanichthys.[1] The bone is extremely dense in this region, and the thickness of the cranium is greater than in any other place. Hence, fragments that have been rolled about or subjected to weathering often become reduced so as to leave nothing but this portion of the occiput.

Dinichthys terrelli Newberry.

This species is numerically the most abundant of American Dinichthyids, and the largest collection of its remains is preserved in Columbia University.[2] The writer, having but one head at his disposal in the Agassiz Museum, has not essayed to figure the cranial osteology, but we may say it does not differ materially from that of *D. intermedius.* The Cambridge specimen shows no evidence of a division of the central into two parts, but the solidifying ridges on the under surface are detached from the cranial bones for a slight distance anteriorly, thus producing the semblance of separate plates.

[1] *Loc. cit.* (1889), Pl. I, Fig. 2; Pl. IV, Fig. 2; Pl. VIII, Fig. 4; Pl. LII, Fig. 1.

[2] Since this article was written the writer has enjoyed the privilege, thanks to the courtesy of his friend Dr. Bashford Dean, of looking over the greater part of Professor Newberry's collection, which has recently been stored in cases in Schemerhorn Hall. No specimens could be found to prove the existence of "parietal" and "frontal" elements, and the conclusion is that they do not occur. A large example of the antero-dorso-lateral with entire margins (embedded in shale) proves that this plate extended underneath the dorso-median and clavicular elements for a distance hitherto unsuspected, the covered area being even greater than the exposed. Newberry's figures of the clavicular in this species are seen to be based upon an imperfect specimen, the superior margin of which has been artificially restored, and is to a certain extent misleading. On the other hand, the collection contains some unusually perfect examples of this plate, which certainly deserve to be figured. There is also abundant evidence to show that the normal condition of the ventro-median plates in *D. terrelli* was one of simple overlap, but, in the adult stage, fusion of the two elements may progressively set in.

The relations of the dorso-lateral plates have been sufficiently treated in former papers, in one of which the writer lamented the fact that no plates corresponding to the laterals of Coccosteus have as yet been brought to light. It seems really quite remarkable that the plate which students of Dinichthyid anatomy have been looking for so long, and has heretofore been regarded as missing, should finally turn out to be one we are all familiar with, and has simply been masquerading under another name these many years. We refer to the "*clavicular*," so named because it was supposed to have formed part of the shoulder girdle. Different writers have made various guesses as to its position on the body. Newberry[1] turned it end for end, its bifurcations being supposed by him to have embraced the antero-dorso-lateral. Claypole[2] considers — "that it was external and ventral can hardly be doubted," — and also confuses rights and lefts. Dean[3] pictures it in his frontispiece as standing vertically and supporting the mandibles.

According to our interpretation, the plate in question has nothing to do with a shoulder girdle, and there is absolutely no evidence that the Dinichthyids possessed paired appendages. The clavicular is in the form of a carpenter's square, roughly speaking; one arm is bifurcated and extends anteriorly and outwardly, the other is single, broad, and flat, and is directed nearly at right angles with the longitudinal axis of the body. The broad arm is homologous with the *anterior lateral* of Coccosteus, and occupies a corresponding position. The heavy ridge on its under side fits into a depression running along the front margin of the antero-dorso-lateral, and its flat expansion overlies a large area of the latter plate, as shown by characteristic markings (see Fig. 3). The same arm also extends across the interval between cranial and dorsal shields, overriding a rounded flange at the base of the external occipital. The sensory canal running down to the posterior apex of the marginal plate is continued on to the clavicular, being traceable along the margin of the transverse arm as far as the right

[1] *Loc. cit.* (1889), p. 142.
[2] *Rep. Geol. Surv. Ohio*, vol. vii (1893), p. 110.
[3] *Fishes, Living and Fossil.* New York. 1895.

angle. Fitting in behind this arm and abutting against the postero-dorso-lateral, as shown by impressions on both, was the *posterior lateral*, a plate not hitherto identified as such. It may be that Newberry's supposed "hyoid (?)" plate[1] occupied this space, but further comparisons are necessary to establish the truth of this inference.

The side plates of the body being now fully accounted for, it may be asked why the name anterior lateral is not substituted instead of "clavicular." The answer is that only one arm of this plate corresponds to the anterior lateral of Coccosteus, while the bifurcated arm represents something entirely different. Hence we must either go on calling the whole structure clavicular, or invent a new name for it; we prefer the former course, although technically the term is a misnomer. It will require a separate article to illustrate the relations of the bifurcated arm, and we will pass over this for the present, remarking only that the inner branch consists of a long thin blade which is probably homologous with the *interlateral* of Coccosteus, and the external curved branch has articulated to it distally a peculiar warped plate, supposed to have formed part of the modified branchiostegal apparatus.

The effect of this orientation of the clavicular is to revolutionize previous notions as to the form of cross-section in Dinichthys and Titanichthys. Instead of being deep-bodied creatures, it is now plain that the more specialized species, with their flat dorsal and abdominal shields and excessively wide cranium, must have had almost ray-like proportions, and this depression of body was no doubt correlated with bottom-feeding. We observe also, which was not suspected before, that the plastron was not in contact with other dermal plates, and covered a relatively small portion of the abdomen. The flat portion of the suborbital probably had a continuous slope with the head shield, its inclination (and also that of the clavicular) being more nearly horizontal than vertical. These relations can best be shown in a side-view restoration, which we hope to present at a subsequent time.

The only writer to attribute an opercular plate to Dinichthys

[1] *Loc. cit.* (1889), Pl. V, Fig. 3.

is Professor Newberry, who figures it (under the designation of "postmaxillary") in his restoration of *D. intermedius*[1] as if suturally united with the suborbital. We have never observed traces on the suborbital indicating a connection with a posterior element, and as its flat expansion reaches in *D. terrelli* almost as far as the posterior angle of the head shield, the opercular either did not occur in this species, or is represented by the hinder part of the suborbital's expansion. *D. intermedius*, however, had a relatively shorter suborbital than the larger species, and theoretically it ought to be followed by a separate plate. Newberry's supposed "eye capsules,"[2] which are preserved in a fairly constant position on the visceral side of the skull, we interpret as *nasal* capsules.

Titanichthys agassizii Newberry.

The cranium upon which this species is founded is unique, and forms one of the principal treasures of the Museum of Comparative Zoology. The mandibles belonging to it, however, are preserved in the Museum of Columbia University, together with all the specimens of *T. clarkii* that have been collected up to within the last few years.

Newberry describes the head of Titanichthys as being "triangular in outline, over four feet broad at the occiput, the nasal portion imperfect in all the specimens known, and the surface smooth or granular, marked by incised lines which form a pattern indistinctly shown in the specimens yet examined." He made no attempt to describe the osteology in either of his species, and the head of *T. clarkii* was not even figured. The "incised lines" (sensory canals) are shown after a fashion in his representation of *T. agassizii*,[3] and their arrangement is still more imperfectly shown in the rough diagrams given by Cope[4] of the same species. As a matter of fact, the sensory canal system is indicated with tolerable clearness on the

[1] *Loc. cit.* (1889), Pl. LII, Fig. 2.

[2] *Ibid.*, Pl. VII, Fig. 2.

[3] *Ibid.*, Pl. I, Fig. 1.

[4] On the Characters of Some Palæozoic Fishes, *Proc. U. S. Nat. Museum*, vol. xiv (1891), Pl. XXXI, Fig. 6.

original head of *T. agassizii*, and enough of the sutures are traceable to give a pretty fair idea of the arrangement of cranial plates. The boundaries of the latter are represented in the accompanying diagram (Fig. 4) by continuous lines as far as they can be made out with certainty, and are dotted in where more or less obscure. Sensory canals are indicated by the usual convention of double dotted lines. The posterior and lateral margins of the skull are entire; the part broken away includes a portion of the preorbitals and pineal and the whole of the rostral (or "ethmoid") plate. It is very evident, however, that the head was more elongated from side to side than in an antero-posterior direction, which is opposite to the usual rule. It is also almost perfectly flat, instead of being transversely arched.

In consequence of the huge size of the head and thinness of the plates, rigidity could only be attained by a nearly complete fusion of the cranial elements, and this rendered the artifice of dovetailing unnecessary. Nevertheless a vestige of the usual interlocking condition remains in the anterior boundary of the central element, where there are a few moderate-sized undulations. Presumably the centrals met each other in the middle along a wavy line, as mechanical principles would seem to require, but the suture itself is now almost wholly obliterated. There is likewise no sort of indication that the space homologous with the central was divided into two components. The pineal plate seems to have been of elliptical outline and longest in a transverse direction. It is extremely attenuated at its lateral edges, where it has been somewhat broken away. Here and along the antero-external margins of the central were the thinnest regions of the cranium, the bone being considerably less than .5 cm. through. The pineal foramen is enclosed in an elliptical capsule of very dense tissue, and opens on the dorsal surface in a circular orifice. An interesting fragment in the collection of Dr. William Clark, of Berea, Ohio, shows that this opening was covered by a thin opercular plate lying loose on the upper surface and undoubtedly movable in life. In another specimen the foramen is seen to be double, the two being separated a slight distance sidewise.

The rostral plate, termed also "nasal" and "ethmoid" by different authors, has been entirely broken away from the type specimen, together with the forward portions of the preorbital plates. The margin of the latter extends for such a distance inwardly in advance of the orbits as to suggest that the head

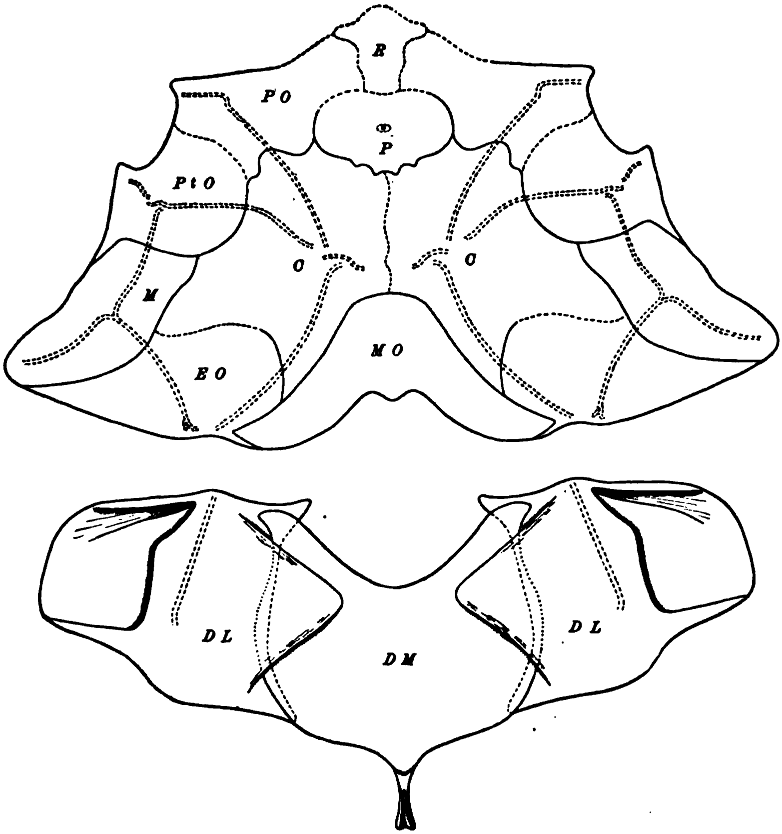


Fig. 4. — *Titanichthys agassizii* Newb. Cleveland Shale, Ohio. Diagram showing cranial and dorsal shields (partly restored). $\times \frac{1}{11}$. Lettering as in Fig. 2.

was foreshortened in the manner shown by the diagram. It is possible, of course, that both rostral and pineal plates were transversely elliptical, instead of the pineal only, as here represented; but in either case the effect on the preorbitals was to give them a very different aspect from the usual condition in the *Coccosteidæ*. These three plates are the only ones which differ markedly from their homologues in Dinichthys.

Newberry's figures show the formation of the nuchal sockets on the under surface of the occiput very clearly. They are quite deep and divided by a thin longitudinal septum, but are not bounded below by a transverse septum, as in *D. terrelli.* The thickness and compact texture of the bone substance in this region are very remarkable, as noted above. The nuchal ridges are broad and massive, but not nearly so prominent as in Dinichthys; and the median longitudinal ridges, together with those belonging to the central ("parietals"), which are so conspicuous in *D. terrelli* and *D. intermedius,* are here altogether lacking.

The arrangement of sensory canals is sufficiently indicated by the diagram, and the articulation of cranial and dorsal shields is so familiar from Newberry's writings that we may pass over these topics. We cannot agree with the latter author, however, that the hinge joint permitted a lateral as well as vertical motion of the head shield, and even the vertical motion must have been restricted in large measure by the overlapping claviculars.

The outline of the dorso-median is reduced from a photograph purporting to be of *T. clarkii,* but, as will be shown presently, there are good reasons for believing it to belong to this species. Not only does it overlap the inner edges of the dorso-lateral plates (for a distance not determinable from the specimen at hand, but probably greater than shown in Fig. 4), but it in turn passes underneath a heavy flange which is given off from the superior surface of the dorso-laterals. The edges of the dorso-median are thus received into a deep groove formed by the side plates; and in another species, as we shall see, the articulation was still further complicated. How far the flange extended backward over the surface of the dorso-median cannot be told with certainty, as it is broken off in the manner shown by Newberry's illustrations.

The term *dorso-lateral* is here used to include the mass of bone contiguous to either side of the dorso-median, the components of which are apparently fused. That two elements are concerned in the formation of this apron-like expanse is patent from a number of features, such as the arrangement of

vascular canals, tenuity of bone substance along the presumable line of fusion, and nature of the free margin corresponding to the postero-dorso-lateral on the right-hand side of the specimen; but no distinct evidence of a suture line is to be observed. It will be remembered that Macropetalichthys also affords an instance of fused dorso-laterals.[1] On the diagrams given herewith all exposed or overlapping margins are shown by continuous lines, and underlapping margins by dotted lines; round dots are used where the dorso-median passes under the flange of the dorso-laterals, and dashes along the overlapped inner margins of the latter plates.

In the region of articulation with the head shield the dorso-laterals are extraordinarily heavy. The thickness even exceeds that of the occiput, being between 5 and 6 cm. through. Great rigidity, however, was necessary in order to hold the claviculars firmly in place. The latter were of huge proportions, but composed of a relatively thin shell of bone. A large area of the dorso-lateral was overlapped by the clavicular, as indicated by shading in Fig. 4, and the heavy ridge on the visceral surface of the latter plate was received into a corresponding deep depression along the anterior margin of the dorso-laterals. Very excellent examples of the clavicular, belonging probably to the next species, are to be seen in the Columbia and Oberlin Museums.

Titanichthys clarkii Newberry.

The dorso-median shown in Fig. 5 is reduced from one of Newberry's illustrations,[2] the original of which the writer has failed to see, although it is said to be still preserved in the Museum of Columbia University. It has not been previously recognized as a dorso-median, Newberry having figured it in an inverted position and referred it to the "under side of the body or head." The dorsal aspect is here represented, and we suspect that the visceral side was embedded in the matrix, since otherwise Newberry could not have failed to observe the

[1] *Amer. Nat.*, vol. xxxi (1897), p. 497.
[2] *Loc. cit.* (1889), Pl. III, Fig. 1, described on p. 135.

median carina. Its slender terminal process must also have been broken off before he saw the specimen.

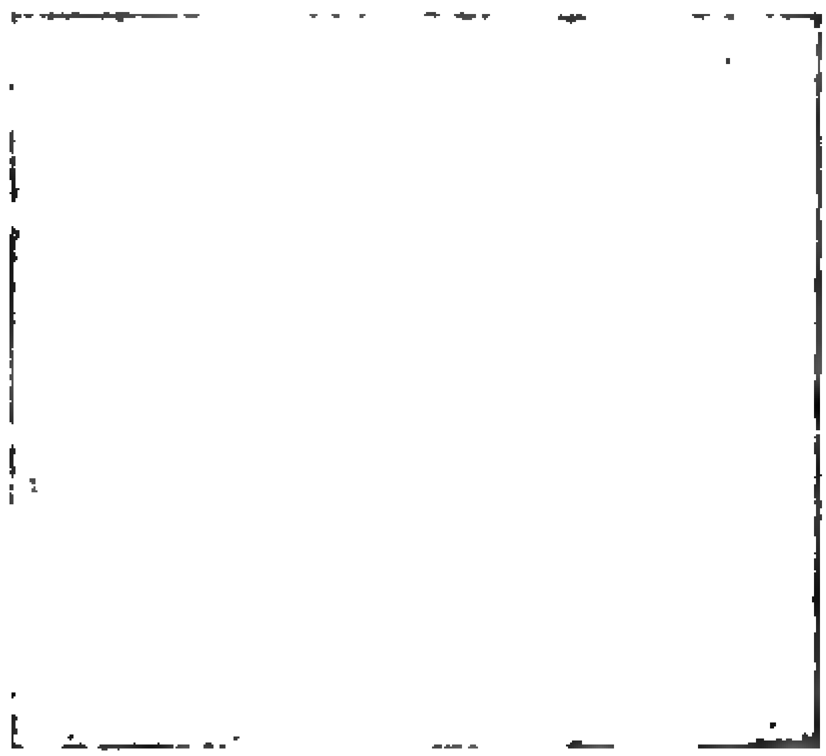


Fig. 5. — *Titanichthys clarkii* Newb. Cleveland Shale, Ohio. Dorso-median plate lacking median anterior spine and cranial process. (Reduced from a figure by Newberry.) × $\frac{1}{15}$.

Fig. 6. — *Titanichthys* (?) sp. Cleveland Shale, Lorain County, Ohio. Visceral aspect of dorso-median belonging presumably to an immature individual. Original in Oberlin Museum. Very nearly natural size.

The chief peculiarity of this plate is the deep indentation of its lateral margins, but this is to be regarded merely as a

specialization of the lobes occurring in the same region among other species, such as *D. ringuebergi*[1] for example, and also in the plate shown in Fig. 6. We may be sure that it had to do with the mode of articulation with the dorso-laterals, perhaps serving for the reception of a ridge given off from the latter. It would naturally be supposed from the figure that the anterior margin was entire, but we cannot avoid a suspicion that a sharply pointed projection in the median line has been broken off, since a similar fragment with associated bones on exhibition at Columbia shows such an anterior projection. Trachosteus, too, has the dorso-median cuspidate in front, but the plate is reduced in size to a mere caricature. Even the small dorso-median shown in Fig. 6, the original of which is preserved in the Oberlin College Museum, shows a broken extension in the median line anteriorly, which may originally have been pointed or triangular. We have reproduced a photograph of this shield, kindly furnished by Prof. A. A. Wright, for the sake of comparison with Fig. 5, as there are several points of mutual resemblance. In fact, the stamp of Titanichthys is so strongly impressed that we must regard the plate either as belonging to an embryonic individual of this genus, or else as representing a pygmy species essentially similar to the Titans. It has a strong anterior emargination, slender antero-external angles, and a relatively large posterior expansion of the dorsal surface, all of which characters are possessed in common with Titanichthys rather than with Dinichthys. Moreover, the antero-lateral margins are deeply lobed, and without question these sinuses are of corresponding nature with the incisions already noted in the dorso-median of *T. clarkii*. It will be understood that the carinal process has been broken away from both specimens, its point of attachment being just underneath the conspicuous posterior expansion of the shield.

Having now identified Newberry's "hyoid (?) or ventral plate" of *T. clarkii* as the dorso-median properly belonging to that species, the question arises, where is the shield to be placed which this author referred to *T. clarkii?* We can only answer, without having seen the specimen, that there is a strong

[1] *Amer. Journ. Sci.* [3], vol. xxvii (1884), p. 477, Fig. 1.

presumption of its having belonged to *T. agassizii.* For we have already noticed that the shield in the latter species is without deep lateral incisions and has no triangular projection in front; and moreover its form (see Fig. 4) agrees with Newberry's statement that "the dorso-median shield is rounded in outline, about two feet in diameter, much thinner than that of Dinichthys, and with a long and relatively slender process, which reaches backward and downward apparently to gain the support of the neural spines."[1] The large size of this particular specimen is, however, remarkable.

[1] *Loc. cit.* (1889), p. 130.

THE WINGS OF INSECTS.

J. H. COMSTOCK AND J. G. NEEDHAM.

CHAPTER IV.

The Specialization of Wings by Addition.

I. THE DEVELOPMENT OF ACCESSORY VEINS.

THE more important of the generalizations reached in the course of the present investigation are two in number; first, the recognition of certain features of the venation of the wings of insects, which occur in the more generalized forms of a large proportion of the orders of this class, has enabled us to present a hypothetical type to which the wings of all orders may be referred;[1] second, if we leave out of consideration the anal area, that portion of the wing traversed by the anal veins, we will find that in nearly every case each order of insects is characterized by either a reduction or a multiplication of the wing-veins; in certain orders the tendency is in one direction, while in others it is in the opposite; but either of these tendencies may be correlated with a similar tendency in the anal area or with the opposite one.

In the preceding chapter we pointed out the various ways in which the number of the wing-veins in the preanal area is reduced. In nearly every case we found the reduction of the preanal area accompanied by a similar tendency in the anal area, or, if a reduction had not taken place, there was no increase in the number of veins of this area, the tendency being towards the production of a few-veined wing. The Trichoptera, however, form an exception to this rule.

We have now to consider several types of wings, in each of which there is taking place an increase in the number of veins of the preanal area, the tendency being towards the formation of a many-veined wing. In speaking of an increase in the number of veins, reference is made only to a multiplication

[1] *American Naturalist*, vol. xxxii (February, 1898), pp. 81–89.

of the branches of the principal veins. In no case is there an increase in the number of principal veins. And this increase in the number of branches may be confined to one or two of the principal veins, while the number of the branches of some of the other veins may be reduced, the expanding of some parts of the preanal area resulting in a crowding of other parts. In some cases we will find that the multiplication of wing-veins extends to the anal area also ; in others we will find the anal area greatly reduced. But even in those cases where the anal area is reduced, the total result has been the production of a many-veined wing.

In the many-veined wings both the longitudinal veins and the cross-veins are increased in number. In most cases where there are many cross-veins it is impracticable to distinguish from others those particular cross-veins to which we applied special names in describing the few-veined wings.[1] But in the case of the longitudinal veins it is necessary to distinguish the primitive veins, that is, those of our hypothetical type, from the veins that have been developed in addition to these. For if this is not done it will be impossible to point out the changes that have taken place in the course of the development of each of the various types of many-veined wings. We therefore apply the term accessory veins to these secondarily developed longitudinal veins, and retain the same nomenclature for the primitive veins that we used in describing the few-veined wings.

Accessory veins may be borne by any of the primitive longitudinal veins ; and they may arise from either of the two sides of such a vein. In most cases it is unnecessary to designate the individual accessory veins, as, usually, it will be sufficient for descriptive purposes to indicate the number of these veins that have been developed upon a particular longitudinal vein. In fact, in certain cases more than this could not well be done owing to the irregularity of the veins. On the other hand, in many cases the accessory veins borne by a single primitive vein present a high degree of regularity, and it is evident that they have been developed in a regular sequence. Under these

[1] *American Naturalist*, vol. xxxii (April, 1898), pp. 233, 234.

circumstances it is practicable to designate them individually; and we have devised the following method for this purpose.

The accessory veins arising from one side of a single primitive vein are considered as a single set, and to each set of veins a distinct set of numbers is applied, beginning with the oldest (*i.e.*, the first-developed) member of the set.

By this method homologous veins, when a homology exists, will bear the same number. But it should be remembered that as accessory veins have arisen independently in many different groups of insects, it often happens that accessory veins similar in position, and bearing the same number in our system, are merely analogous and not homologous.

In order to apply this system it is necessary to know, in the case of each group of insects studied, the sequence in which the members of the particular set of veins under consideration have been developed. For additions to such a set of veins may be made to the distal end of the series, or to the proximal end, or may be interpolated at some distance from either end.

Frequently an examination of the wing of an adult insect is sufficient to determine this sequence. But the determination can be made in a much more satisfactory manner by a study of the tracheation of the wings of the nymph or pupa. For in the many-veined insects the longitudinal veins, both primitive and accessory, are developed about tracheæ; and it is much easier to determine the homologies of the tracheæ of an immature wing than it is to determine the homologies of the wing-veins of the adult. And, too, in this way we are able to eliminate the cross-veins which are not preceded by tracheæ in the forms used for illustration here. We will, therefore, use for this purpose the wings of immature insects.

Accessory veins added distally. — If the radial tracheæ of the pupa of Chauliodes (Fig. 53) and of the pupa of *Corydalis cornuta* (Fig. 54) be examined, it will be seen that both differ from our hypothetical type in the presence of a greater number of branches of the radial sector. And a comparison of the two figures shows that the increase in the case of Corydalis has been greater than in the case of Chauliodes. Farther, the presence of fine twigs at the tip of the trachea R_5 indicates the

method of increase, which is doubtless as follows: the branches have been added one after another to the tip of trachea R_2, there being a migration of the base of each accessory trachea towards the base of the wing, thus making room for the addi-

FIG. 53. — Wing of a pupa of Chauliodes.

tion of new branches. In this case the first accessory vein is the proximal one.

In Sialis (Fig. 55) the accessory veins have been developed in a similar way, but they are on vein R_3 and on the cephalic side of this vein. Here, too, the first accessory vein is the proximal one. But it should be noted that the numbers of the veins increase in the opposite direction from what they do when the

FIG. 54. — Wing of a pupa of Corydalis.

accessory veins are added distally on the caudal side of a primitive vein, as in the radial sector of Chauliodes and Corydalis.

Accessory veins added proximally. — A good illustration of the adding of accessory veins to the proximal end of a series is afforded by the accessories of vein Cu_1 in the Blattidæ. Fig. 56 represents the hind wing of a nymph of a cockroach. An

examination of the set of accessory veins borne by vein Cu_1 shows that the distal members of the series are well developed, and that the growth of additional veins is taking place in the disk of the wing at the proximal end of the series. In this case the first accessory vein is the distal one.

Accessory veins interpolated. — In the wing of the cockroach

FIG. 55. — Wing of a pupa of Sialis.

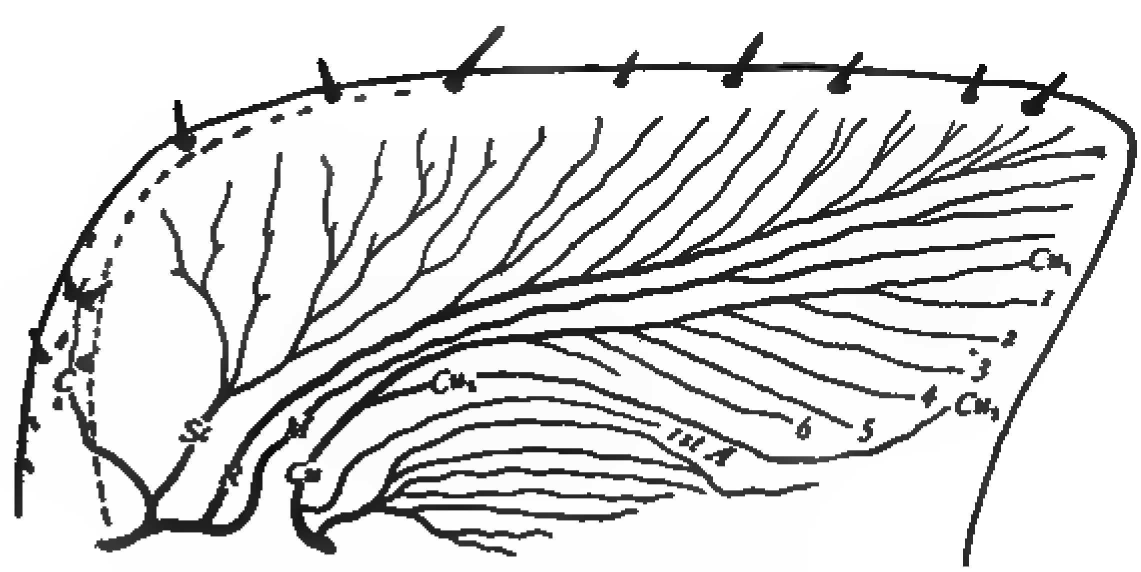


FIG. 56. — Hind wing of a nymph of a cockroach.

represented by Fig. 56 there are many accessory veins borne on the cephalic side of radius. From the presence of the fine twigs near the apex of the wing, it is evident that accessory veins are being added distally. It is also evident that the number of veins is being increased by the splitting of certain of the older veins, *i.e.*, by interpolation. In cases of this kind it is impracticable to number the members of a series of accessory veins.

II. The Suppression of the Dichotomous Branching of Veins.

In the more highly specialized of the many-veined insect wings there exists a type of branching which is very different from that of our hypothetical primitive type. An examination of Fig. 57, which represents this type, will show that in every case the forked veins are branched dichotomously, while in the many-veined wings the more characteristic type of branching results in the formation of pectinate veins; this pectinate type of branching is well shown by the radial sector of Corydalis (Fig. 54).

The prevalence of the pectinate type of branching in the many-veined wings has been, doubtless, the greatest obstacle

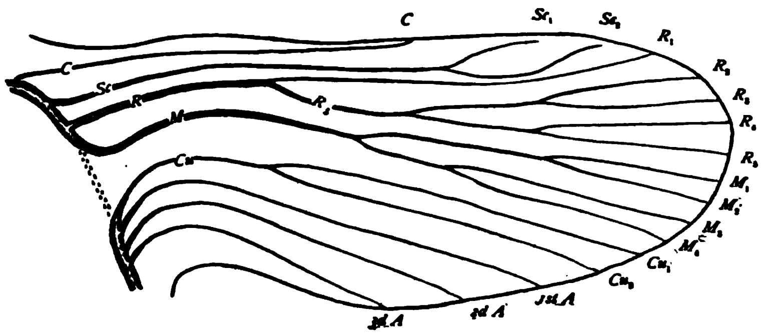


Fig. 57. — Hypothetical type.

to a recognition of the homologies of the branches of the forked veins in such wings. Our hypothetical type was first worked out by a study of the few-veined wings; but it was a long time after that was accomplished before we saw that the pectinate type of branching had been derived from the same type. The most potent factor in reaching this conclusion was the fact that in some of the many-veined insects the dichotomous type of branching has been preserved. Good illustrations of this can be seen in the neuropterous genus Sialis (Fig. 55), while equally good examples of the pectinate type are presented by the closely allied genera Chauliodes and Corydalis (Figs. 53, 54).

The changes that take place in the development of the pectinate type of venation from the dichotomous type are of two

kinds: first, the development of accessory veins; second, the modification of the primitive veins so that they are no longer dichotomously branched. The former has been discussed above; we will now briefly refer to the latter. For this purpose we will give a series of diagrams illustrating several types of branching of the radial sector.

Fig. 58*a* represents the typical or dichotomously branched radial sector. Fig. 58*b* represents a typical radial sector with the addition of some accessory veins on the caudal side of vein R_2. Such a radial sector occurs in the fore wing of Ithone.[1] In this case the radial sector is nearly pectinate, but not quite so, owing to the forked condition of vein R_{4+5}. In Chauliodes (Figs. 53, 58*c*) veins R_4 and R_5 coalesce to the margin of the wing; and in this way the pectinate type is attained. In Hemerobius (Figs. 58*d*, 59) the pectinate type has been attained by fission instead of coalescence. Here veins R_4 and R_5 have split apart till vein R_5 arises from the main stem of radius.

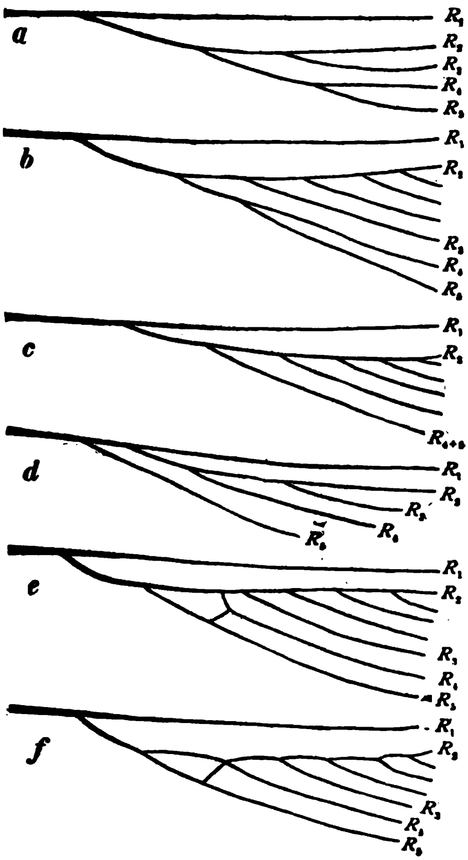


FIG. 58. — Diagrams of several types of radius.

When many cross-veins are present, the dichotomy of the branching of the sector may be suppressed in still another way, by the transference of the base of vein R_4 to

[1] Brongniart. *Rech. sur l'Hist. d. Insectes Fossiles*, Pl. I, Fig. 10.

vein R_{2+3}. All stages of this switching of vein R_4 occur in the Myrmeleonidæ; but two examples will suffice to illustrate it. In Myrmeleon (Fig. 58*e*) the base of vein R_4 appears to be forked; one arm of the fork arising from vein R_5, the other from vein R_{2+3}. The former is the true base of vein R_4; the latter is a cross-vein which is assuming the function of a base of this vein. In the hind wing of *Ptynx appendiculatus* (Fig. 58*f*) the switching has been completed, vein R_4 arising from vein R_{2+3}.

In the foregoing illustrations comparisons of allied insects have been made in order to determine the ways in which the wings are being modified; frequently a comparative study of the fore and hind wings of a single insect is equally suggest-

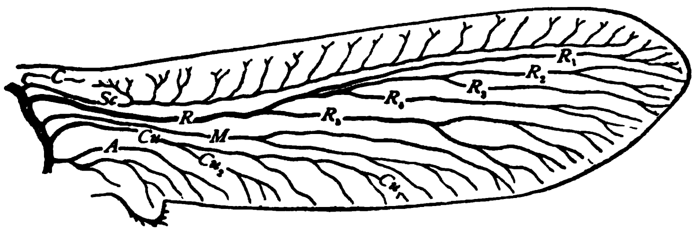


FIG. 59. — Wing of a pupa of Hemerobius.

ive, for it often happens that the two pairs of wings exhibit different degrees of the same kind of modification, and thus the course of the change is indicated.

A study of the causes of the changes which we are describing is beyond our present purpose, which is merely to determine the homologies of the wing-veins. But we can gain a hint of the probable reason for the development of the pectinate type of veins without entering very deeply into questions of the mechanics of flight.

It is obvious that many styles of flight exist among insects, and that for the different styles of flight different kinds of wings are required. In Corydalis (Fig. 54) the wing is stiffened, along a line parallel with the costal margin of the wing, by the subcosta, the main stem of the radius, and veins R_1 and R_2. Back of this line there is a broad, flexible area, which bends up during the downward stroke of the wing, forming an inclined plane, the pressure of which against the air forces the

insect ahead. The flexibility of this area of the wing is increased by those changes which result in the formation of the pectinate type of branching.

The extreme of the pectinate type of branching exists in the neuropterous genus Polystœchotes, in which the area traversed by the parallel veins is very broad.

NOTE ON THE VARIATIONS IN THE TELEUTO-SPORES OF PUCCINIA WINDSORIÆ.

JOSEPH ALLEN WARREN.

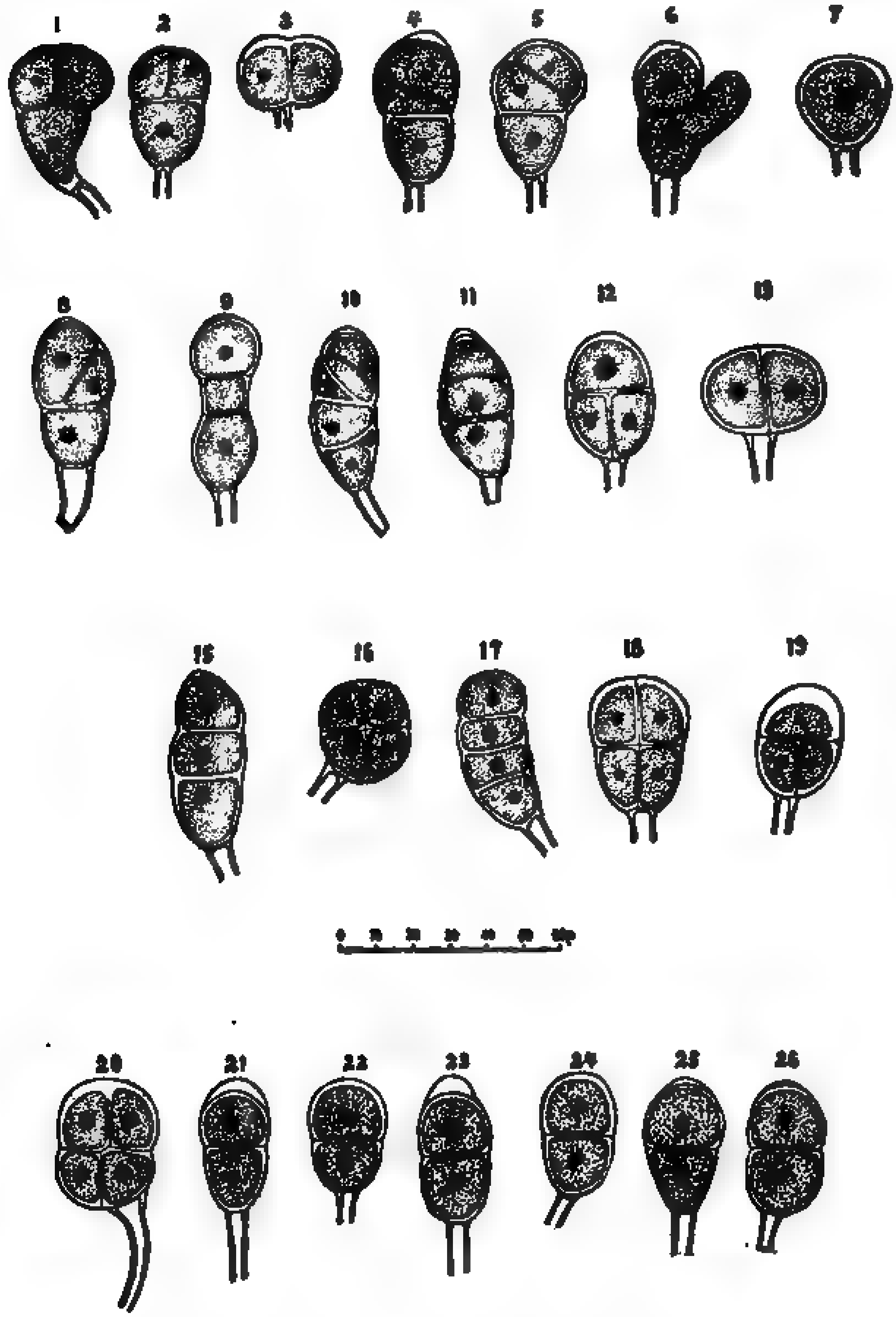
EVERY one who has studied the rusts has observed that the teleutospores are often very irregular in their general shape, number of cells, and the relation of the cells to one another. This fact has frequently been recorded, and is often referred to in books and papers on the Uredineæ. In studying the teleutospores of *Puccinia windsoriæ* Schw., collected in a scattered maple grove on the "bottom land" bordering a small creek near Lincoln, Neb., March 31, 1898, on *Muhlenbergia racemosa* B. S. P., I found some more than usually interesting forms, which are shown in the accompanying plate.

In the genus to which this species is referred there are two cells in the teleutospore, as shown in Figs. 21–26, but a reference to the plate shows one-celled, two-celled, three-celled, four-celled, and five-celled forms. Normally also the two cells lie in the extension of the axis of the pedicel, as in Figs. 21–23 and 25, but all kinds of departures from the normal may be observed on the plate. Out of 572 spores counted in several mounts from different leaves, the microscope fields being taken at random, I found 27 abnormal spores, or about 4¾ per cent. On some leaves the proportion of abnormal spores was much higher, and in one cluster of 11 spores still holding together in the mount, five had more than two cells.

Of the 572 spores referred to above —

1 (or 1.93 per cent) were three-celled, with septa parallel.
12 (or 2.10 per cent) were three-celled, with septa in two planes.
1 (or .17 per cent) was four-celled, with septa in one plane.
1 (or .17 per cent) was one-celled.
2 (or .35 per cent) were turned upon their pedicels.

In other mounts I found several four-celled spores, with the septa in two planes, as in Figs. 16, 18, and 20.



FIGS. 1 and 2.—Three-celled form, with single cell basal. Figs. 3 and 13.—Two-celled form, turned upon the pedical. Figs. 4, 5, 8, and 10.—Forms intermediate between 1, 2, and 9, 11, 14, 15, 17. Fig. 6.—Two-celled form, with lower cell branched. Fig. 7.—One-celled form. Figs. 9, 11, 14, 15, and 17.—Three and four-celled forms, with septa parallel. Figs. 12 and 19.—Three-called form, with single apical cell. Figs. 16, 18, and 20.—Four-celled form, with septa at right angles. Figs. 21 to 26.—Normal form. (Scale of micro-millimeters on plate.)

If the variations found in these specimens were to become permanent, we should have representatives of at least four genera in this single species, or we should have to discard or modify our present notions as to the relationship and classification of Uredineæ. It may be that the morphology of the teleutospore is not to be considered of as much importance as we have supposed. One-celled teleutospores (Fig. 7) are common, and if these should eventually predominate the species must be referred to Uromyces, or Melampsora, instead of Puccinia. If such forms as Figs. 1, 2, 12, and 19 become most common, we must refer the species to Triphragmium. The forms shown in Figs. 16, 18, and 20 may be allied to the latter, with an additional septum. If spores like Figs. 4, 5, 9, 11, 14, 15, and 17 were most numerous, we could not avoid referring the species to the genus Phragmidium. Yet all these forms have been found in this species, often on the same leaf, and nearly all have occasionally been found in the same sorus. In my specimens nearly every leaf contained a number of several-celled spores, but I found them more numerous on the leaves which lay near the ground, those which stood free in the air bearing fewer abnormal spores.

The normal spores agree well with Burrill's description in his "Parasitic Fungi of Illinois," [1] though more variable in size. I measured 58 spores and found them to be 16.8 to 24 μ by 26.4 to 48 μ, averaging 20.8 by 34.3 μ, while Burrill's measurements are 18 to 21 by 27 to 30 μ.

I have examined herbarium specimens of this species from Iowa, Illinois, and Nebraska (Lincoln, 1889), but found no spores with more than three cells.

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[1] Parasitic Fungi of Illinois, Pt. i, Uredineæ, by T. J. Burrill, in *Bull. Ill. State Lab. Nat. Hist.*, 1885.

EDITORIAL.

A Marine Biological Station for Canada. — At the Toronto meeting of the British Association, a proposition was brought forward in the Botanical Section for the establishment of a biological station in the Gulf of St. Lawrence. So strongly did this appeal to those interested that the Sections of Zoology and Physiology asked to be allowed to participate in the movement, with the result that a committee was appointed to take such steps as might be necessary. This committee consisted of Prof. E. E. Prince, Chairman; Dr. A. B. Macallum, Prof. John Macoun, Dr. T. Wesley Mills, Prof. E. W. MacBride, Dr. W. T. Thistleton-Dyer, of the Royal Gardens, Kew; and Prof. D. P. Penhallow, Secretary.

In March last this committee, supported by a very strong deputation representative of the fishing interests and of the leading universities of Canada, approached the government through the Minister of Marine and Fisheries with the request that an appropriation be made to cover the cost of establishing such a station for a certain term of years.

According to the terms of the request, the station is to be a floating one, and will be established in the Gulf of St. Lawrence for a period of five years; it will be established first on the south shore of Prince Edward Island, and be moved annually to a new location as required; the various universities and scientific bodies of Canada will be granted certain privileges with respect to opportunities for qualified investigators; the scientific work will be executed as far as possible by experienced investigators connected with the various universities; that while the station remains a government institution, the administration is to be vested in a Board consisting of one or more representatives from the Department of Marine and Fisheries, and one representative from each of the leading universities.

The committee received a favorable reply to its request, and the government made an appropriation of $7000 to cover cost of construction and outfit and expenses for the first year, thus substantially guaranteeing its support for the experimental period of five years.

The Board of Management, as now constituted, consists of Prof. E. E. Prince, Director; Prof. D. P. Penhallow and Prof. E. W.

MacBride, of McGill University; Prof. Ramsay Wright, of Toronto University; Prof. L. W. Bailey, of the University of New Brunswick; Prof. A. P. Knight, of Queen's University; Rev. V. A. Huart, of Laval University.

It is probable that all plans will be perfected during the coming winter, so that active work may commence with the opening of the season of 1899. It would be altogether premature to discuss the policy of this station, but there is reason to believe and hope that it may establish such relations with kindred institutions as to prove of mutual advantage without intruding upon the special work now carried on in other localities. Its future will be watched with much interest.

REVIEWS OF RECENT LITERATURE.

A Teacher's Guide in Nature Study. — Teachers who appreciate the importance of enriching elementary education by natural history studies, and realize something of the difficulties to be met, will doubtless greet with hopeful interest the announcement of a schoolteacher's contribution toward a solution of the problem.[1] Although on the title page it is said to be "for teachers and pupils," a perusal of the book shows it to be little more than a guide for teachers, and quite unsuitable for children's use. Its purpose is better indicated in the preface as an attempt "to point out some of the material which may be made the basis of profitable lessons in nature study," and an endeavor "to show how this material may be made available, and what the pupils may be taught about it."

In his effort to suggest profitable lines of instruction the author has had some measure of success. The natural interests of children are followed in calling attention to common animals, plants, and rocks, and indicating how each affects the others. Questions are asked which are calculated to stimulate observation. Simple and significant experiments are encouraged. Regarding certain of the objects dealt with, notably domestic animals and cultivated plants, there is given information likely to be of service to teachers in preparing nature lessons. References to good literature on the various topics are not infrequent, although sometimes their value is lessened by lack of definiteness. The illustrations, a good share of which are original, are generally good.

On the other hand, it must be said that the book gives the unfortunate impression of being mainly a collection of notes prepared by the author for use in his daily lessons with children, some of the notes being the merest skeletons of topics for treatment, while others are expanded as examples of the way he would talk to a class. There often results a somewhat puzzling mixture of the audiences supposed to be addressed, and much of what is said seems entirely unnecessary. There are, moreover, frequent evidences of hasty preparation,

[1] *Handbook of Nature Study for Teachers and Pupils in Elementary Schools.* By D. Lange, Instructor in Nature Study in the Public Schools of St. Paul, Minnesota. The Macmillan Company. New York, 1898. xvi + 329 pp. 60 illustrations. Cloth, 12mo, $1.00.

slips in English, and loose statements. Misstatements and misuses of technical terms are altogether too numerous, even for a first edition. Of these a few examples must suffice. On page 233 we read that the Kentucky coffee tree "has the most compound leaves of all American trees"; on page 2 a tulip flower is said to consist of six leaves; on page 187 occurs the statement that "corn is the only grass which bears the sterile and fertile flowers on separate heads"; and on page 4 sepals are called leaflets. In spite of these defects, however, we should say that teachers may gain from this book not a little of profitable fact and hint if they are disposed to have due patience in overlooking much that seems crude and practically valueless.

FREDERICK LEROY SARGENT.

Needham's Outdoor Studies.[1] — With the rapid development of "nature study" in the American schools has come a marked increase in the putting forth of nature study books. A good nature study book should be, above all, truthful; its telling of nature should be accurate. Then it should be readily comprehensible, and written so as to attract and to hold the interest of its intended readers, be they teachers or children or both. Professor Needham's little book possesses the qualifications just enumerated. The author is a careful and intelligent naturalist, and writes from personal observation and experience. He writes simply, and he writes interestingly. *Outdoor Studies* is certainly one of the good nature study books.

The book is written, suggests the author, especially for the children. It is insistent in its demands for personal work by the student in "seeing and doing and thinking," and explicit in its explanations of how to do this work. There are chapters on flowers and insects and chipmunks and birds under such titles as "Butter and Eggs and Bumblebees," "Goldenrod, its Visitors and Tenants," and "Houses that Grow" (galls and gall insects). The book is charmingly and helpfully illustrated, and the big scientific names, whose value is not overlooked but whose fear-inspiring capacity is fully recognized, are disposed of in a unique and effective way. Altogether the book is one to recommend to teachers, to parents, and to the children, for whom it is primarily written.

V. L. K.

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[1] *Outdoor Studies, A Reading Book of Nature Study.* By James G. Needham. Eclectic School Readings, American Book Company. New York, 1898.

ZOOLOGY.

Parker and Haswell's Zoology.[1] — For many years there was no greater need in teaching zoology than a good text-book on the subject — one which should treat the subject from a modern morphological standpoint. One need not go back more than four or five years to find the time when Sedgwick's translation of Claus was the only such work available. This real need has been met, and perhaps more than met, in the last few years by the translation of several works from the German, and by new publications in the English language. Among the books on this subject which have been anxiously awaited by teachers of zoology was the long-promised work by Parker and Haswell, which has recently appeared. Parker's text-book on zootomy and on elementary biology were evidence that one of the authors, at least, thoroughly understood the needs of the elementary student. It may be doubted whether any book in any language presents the facts of elementary biology in a more attractive manner than does Parker's text-book on this subject; and it was to have been expected that the new book on zoology would be preëminently a student's text-book, clear, concise, and attractive. In this respect no one will be disappointed with the work. The authors show at every step that they are, before all else, teachers, and that they know how to present the facts of zoology in a way which, even to the laity in such matters, is intelligible, interesting, and instructive.

In spite of its size the authors expressly affirm that the work is addressed to the needs of elementary students, but it is to be feared that both the size and the cost of the work will effectually prevent its coming into very general use among persons of this class. Almost all recent English works on zoology seem to show that it is no longer possible to condense into a single volume the elements of the whole science. On the other hand, some notable German text-books on this subject are much more limited in extent, while no less accurate and satisfactory; *e.g.*, the works of Boas and Hertwig occupy, respectively, 578 and 576 pages, and few, if any, better text-books on zoology can be found in any language. Hatschek's work is unfortunately still a fragment, but where is there another such a text on the field which it covers? These German works show that it is possible to

[1] Parker, T. Jeffery, and Haswell, William A. *A Text-Book of Zoölogy.* Macmillan & Co. 1897. 2 vols., 779 pp. and 683 pp.

present the subject within a single volume, and in a manner which is both thorough and attractive. And by this same showing it is evident that the book which will be used by large numbers of English students has not yet appeared.

The distinctive feature of Parker and Haswell's work is the way in which the study of "types," or "examples" as our authors prefer to call them, is united with the more usual methods of descriptive zoology. Believing that definitions and general descriptions can be useful only after the student has obtained some first-hand knowledge of the things described, our authors begin the study of every group with a description of some single example of that group, which should be thoroughly studied in the laboratory before undertaking the study of the group as a whole. The value of this departure, no one who is a thorough believer in the laboratory method can for a moment doubt; that it has its dangers none can deny. If the study stops with a few examples, it is narrow and misleading; if it covers the whole field by means of a text-book and a few museum specimens, it is superficial. A proper combination of the two methods, which would secure the advantages and avoid the disadvantages of both, would be ideally perfect.

Such a combination our authors have attempted, and, as it seems to us, with signal success. "Every group which cannot be readily and intelligibly described in terms of another group" is represented by an example. The descriptions of these examples are concise and yet comprehensive, and this part of the work might well be used as a laboratory guide were it not for the fact that the authors have been so cosmopolitan in their choice of examples, some of which are peculiar to Australia, others to New Zealand, others to Great Britain, and still others to the Mediterranean. In most cases, however, alternative forms are suggested which might serve in the place of the example described.

Following the description of the examples there is given the classification of the group which it represents, then a detailed description of its various subdivisions, and finally a general discussion of the organization, embryology, ethology (œcology), distribution, and affinities of the group as a whole.

In accordance with the plan of presenting specific facts before the general ones, the discussion of distribution, the philosophy of zoology, and the history of zoology, with references to the general literature, is put at the end of the work. However, in order to render the body of the work intelligible to elementary students there is at the begin-

ning a general introduction on the subjects of classification, anatomy, and physiology.

In spite of many excellences, the general part of the work is not wholly satisfactory; it is distinctly inferior to the *Allgemeine Zoologie* of Claus, Hertwig, or Hatschek. Again, it seems to the writer unwise, both from a pedagogical and from a scientific standpoint, to erect any artificial barrier between the philosophy and history of a science and its bare results. The deadest, driest facts may be clothed with a living interest if only the historical discovery of those facts and their philosophical import are pointed out at once.

Twelve phyla of the animal kingdom are recognized instead of the classical seven of Leuckart, the modifications being the following: the Porifera are separated from the Cœlenterata; Vermes is omitted, and in its place are three phyla, *viz.*, Platyhelminthes (including Nemertinea), Nemathelminthes (including Chætognatha), and Annulata; a new phylum, Trochhelminthes, includes Rotifera, Dinophilea, and Gastrotricha; Molluscoidea stands as a phylum, including Polyzoa, Phoronida, and Brachiopoda.

The first eleven phyla are treated of in the first volume of the work; the second volume is devoted entirely to the twelfth phylum, the Chordata. Each volume is indexed and is complete in itself, and this fact may be utilized to advantage by teachers who conduct separate classes in Vertebrate and Invertebrate Zoology.

The illustrations and typography are excellent in the main. Some of the figures suffer from being copies of copies, but many of them are entirely new, and others are new to a text-book. Both the illustrations and the method of presenting the subject give a freshness to the whole work which is very attractive.

Unfortunately the work is marred by an unusually large number of errors.[1] This is certainly due in part to the fact that the authors were separated so far from each other and from the publishers, and perhaps also to the serious illness of the senior author, who, unfortunately, did not live to see the completion of the work.

Some Recent Faunistic Work in Europe. — Two papers of importance have appeared recently which deal with the fresh-water fauna of Central Europe and exemplify in some particulars the tendencies of current faunistic and systematic work in zoology. For many years Bohemia has been a center of activity in these lines, and the portable

[1] For a list of these errors see a review of the work in *Natural Science* for March, 1898.

biological station under the direction of Professor Frič has had a large share in this work. The latest publication from this station is a paper[1] which deals with the flora and fauna of two glacial lakes in the Bohemian Forest. These lakes have an altitude of 1008 and 1030 meters, and a maximum depth of 30 and 35 meters, respectively. They are characterized by rocky shores, little vegetation, and great transparency of the water. As might be expected under these conditions the fauna is scanty, including, with the adjacent land forms, only 185 species, of which but 83 are referred to the aquatic fauna. This is characterized by the presence of a number of cosmopolitan species, principally of Protozoa and Entomostraca, together with a much smaller number of alpine and arctic forms. The cosmopolitan distribution of the two groups above mentioned is shown by the fact that of 19 species of Protozoa listed for these Bohemian lakes, 13 are known to occur in this continent, and of the 24 species of Entomostraca at least 12 are found in American waters. A further evidence of the similarity of the lake fauna the world over is found in the occurrence in these alpine lakes of Bohemia of 12 species, largely limnetic, reported by Forbes[2] from the mountain lakes of Yellowstone Park.

These lakes of Bohemia were under observation in 1871, in '87, and again from '92–'96 at intervals during the summer months. With respect to the fauna thus observed, the authors conclude that it is not constant but changes from year to year in response to the environment, predominant forms of one year disappearing the next, it may be to return again when conditions favor. Thus the authors attribute the disappearance of *Polyphemus pediculus*, a littoral species in Schwarzersee, to the accidental lowering of water level, whereby the winter eggs were stranded on the dry shore, and the extermination of *Holopedium gibberum* from the plankton to the introduction of *Salmo salvelinus* into the lake. A single fish (32 cm.) of this species was taken which had eaten 3000 specimens of Holopedium. The plankton is remarkable for the paucity of species reported. In general the collections, which were not strictly quantitative, indicate an accumulation of the plankton in the upper layers and its scarcity in the deeper water, though one instance occurs of an exceptional abundance of *Daphnia ventricosa* — with summer eggs — in the

[1] Frič, A., und Vavra, U. Untersuchungen zweier Böhmerwaldseen, des Schwarzen und des Teufelssees. *Archiv f. Landesdurchforsch. v. Böhmen*, Bd. x (1897), Nr 3, 74 pp., 33 figs.

[2] Forbes, S. A. A preliminary report on the aquatic invertebrate fauna of Yellowstone National Park, Wyoming, and of the Flathead region of Montana. *Bull. U. S. Fish Com.*, vol. xi (1893), pp. 207–258, Pls. XXXVII–XLII.

bottom water at a depth of 25 meters. The bottom ooze of the lakes is declared to be practically devoid of life.

The second paper[1] is issued by the Balaton Lake Commission of the Hungarian Geographical Society, as Part I of a volume dealing with the biology of this body of water, a lake containing 650 square kilometers, but having an average depth of only 3 meters and a maximum of 10. The presence of vegetation, the warm shoal water, and the variety of conditions offered in so large a body of water favor the occurrence of an extended and varied fauna. It is therefore not surprising that the zoological inventory includes 597 species reported by the specialists who have dealt with the various groups.

The introductory chapter by Dr. Entz contains a description of Daday's ingenious closable trap for bottom collections and an extended comparison of the pelagic fauna of the Balaton with that of other bodies of water which have been similarly explored. Owing to the fragmentary character of the data, precise comparisons are not possible, though in a general way it may be said that the organisms of the plankton are, as a rule, cosmopolitan in their distribution. Attention is called to the invasion of the littoral region by the plankton organisms and the depth of 1.5 meters is stated to be the limit of the purely plankton-inhabited area of Lake Balaton. That this limit cannot be generally applied must be evident. The reviewer has often found a typical plankton in water much less than a meter in depth. The character and extent of the littoral fauna, and especially of the flora, the distance from shore, and a host of environmental conditions come in to establish, obliterate, or modify the boundary lines of the limnetic and littoral areas in most bodies of fresh water. Aquatic vegetation is said to hinder the development of the plankton, and the author maintains the diurnal migration of the plankton organisms, — to the surface at night and to the deeper waters during the day. No data upon this subject are given, and it may be well in this connection to recall the results of Professor Birge's careful quantitative work[2] upon the movements of the *Crustacea* in Lake Mendota. In this body of water the diurnal migration, occasioned by the light, is confined to the upper meter or possibly two meters.

[1] Die Fauna des Balatonsees, von Dr. K. Brancsik, Dr. E. v. Daday, R. Francé, Dr. A. Lovassy, L. v. Méhelÿ, Dr. S. v. Ratz, Dr. K. Szigethy, und Dr. E. Vángel, unter der Leitung von Dr. G. Entz. Wien, 1897. xxxix + 279 pp. 158 illustrations.

[2] Birge, E. A. Plankton Studies on Lake Mendota. II, The Crustacea of the Plankton, July, 1894 — December, 1896. *Trans. Wisc. Acad. Sci., Arts, and Letters*, vol. xi (1897), pp. 274–448.

The plankton of the Balaton is peculiar in its entire lack of Dinobryon and Difflugia. The fauna seems to be relatively poor in Rotifera and Entomostraca and rich in Nematoda and Protozoa, especially Flagellata. For these last particulars much credit must be given to the excellent reports of Daday and Francé. Of the Protozoa 191 species were found, 92 belonging to the oft-neglected group of Mastigophora. The bottom ooze yielded an unusual number of new forms.

With regard to the distribution of Protozoa, Francé concludes that it is not so much influenced by climatological and meteorological conditions, as by the hydrological environment and the associated vegetation. Thus he distinguishes several characteristic habitats, each having its peculiar protozoan fauna wherever found, such as (1) the peat swamp where desmids and Protococus abound, and the green flagellates as Euglena are plentiful; here we find the Rhizopoda with patterned shell, such as Euglypha and Nebella, which feed upon the green forms mentioned; (2) decaying vegetation, where Stentor, Paramœcium, and craspemonads occur; (3) the rush-bordered shore, where diatoms abound, and the diatomophagous Protozoa, such as Amœba, the Euglenidœ, Chilodon, Holophrya, and Amphileptus, abound; (4) the bottom ooze, resembling the shore but not so densely populated, where *Amœba verrucosa*, Arcella, and Difflugia, and small monads are to be found; (5) the sandy shore, marked by the sand building Rhizopoda, as Difflugia, and Orbulinella; (6) the rocky shore, where filamentous algæ cover the rocks and afford food and shelter for the algophilus Infusoria, such as Glaucoma and Colpoda, and for the thalamophorous Rhizopoda; (7) the open water with its typical plankton forms, such as the Peridinidæ, Codonella, Synura, and the passive limnetic Epistylis and Tokophrya. It is of interest to note that Daday finds these same habitats characterized each by its peculiar crustacean fauna. He also mentions the avoidance of the upper layers of water by the Entomostraca in the daytime and on moonlit nights, and discusses their movements with respect to light.

An interesting case of "synoikosis" is reported by Vángel in which a bryozoan, *Fredericella sultana*, is associated with a sponge, *Spongilla lacustris* or *fragilis*. There is a marked and constant agreement in the color of the two forms, the bryozoan being of a grayish, brownish, or greenish tinge according as the sponge is colored. The author suggests that the similarity in color affords mutual protection, that the tentacles of the bryozoan create currents which bring more food to the sessile sponge, and that by reason of its

likeness in color to its background the bryozoan escapes detection when extended from its capsule. From the structure of the sponge it is evident that it is not located upon the bryozoan until the latter has attained a considerable growth.

Although a considerable number of new species are described in this report, we find an occasional reduction of an old species to a synonym as a result of the examination of this fauna through several seasons, and a few incidental references to the variability of characters relied upon for specific distinctions.

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Lake Fauna. — The results of three summers' careful investigation of the life in a small lake in Finland are given in a faunistic-biological paper by Dr. K. E. Stenroos,[1] which amply proves the sufficiency of a small body of water to yield a rich fauna and to throw light on many important biological problems. Lake Nurmijärvi contains but two square kilometers, is but one meter in depth, presents a variety of shore formations, and is rich in vegetation. It is subject to considerable fluctuation in level and in temperature and to much shifting of the bottom by the ice in winter.

The author's faunal list includes 460 species, of which 157 belong to the Rotifera and 98 to the Entomostraca. The absence of nematodes, the paucity of Infusoria, and the small number of aquatic insects enumerated are probably due to the lack of especial attention to these groups, such as was given to the Rotifera. In this latter group 27 new species are described — the under surface of lily-pads having proved to be an inexhaustible source of new forms. In this list of Finland rotifers are to be found three species discovered by Jennings[2] in the Great Lake region of this continent. Among the Entomostraca Stenroos finds a seasonal polymorphism which renders necessary a considerable reduction in the number of species in this group. Thus from spring to autumn *Hyalodaphnia jardinii* is successively represented by forms which have been described as *H. obtusata*, *berolinensis*, *cucullata*, *kalbergensis*, and *autumnalis*. Likewise in the genus Bosmina the author admits but five species,

[1] Stenroos, K. E. Das Thierleben im Nurmijärvi-see, eine faunistisch-biologische Studie. *Acta Soc. pro Fauna et Flora Fennica*, Bd. xvii, pp. 1–259, Taf. I–III, mit einer Karte.

[2] Jennings, H. S. A List of the Rotatoria of the Great Lakes and of Some of the Inland Lakes of Michigan. *Bull. Mich. Fish Com.* (1894), No. 3. 34 pp., 1 pl.

the remaining twenty-two being recognized as varieties, or in some instances as mere seasonal or habitat forms. Two types of contemporaneous males are described for *B. brevirostris*, and are also stated to occur in *B. lilljeborgii*. One of the two exhibits a marked resemblance to the female in its secondary sexual characters, — armature of the post-abdomen and structure of the antennæ. The author suggests that this dimorphism may be serial in the life history of the male, representing two stages separated by a molt.

Although the lake is a small one, it presents a number of well-marked faunal areas, determined largely by the nature of the substratum and of the vegetation. Full lists are given of the characteristic faunas, and the adaptations exhibited by their constituent organisms are discussed at length. We note that no mention is made of the pelagic habit of many Rhizopoda, and that the author ranks Dinobryon, Hyalodaphnia, and Diaphanosoma as tycholimnetic organisms — forms which in most bodies of water are typical planktonts. Attention is called to the uneven distribution of the Cladocera occasioned by the influence of light. At night they are dispersed through the water, on cloudy days they congregate in the upper strata, but on bright days they gather in great swarms on the sunny side of clumps of Scirpus, shifting their position as the day advances. The Copepoda and Ostracoda, on the other hand, appear to be indifferent to the influences of light to which the Cladocera show so marked a response.

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The Embryonic Development of the Wall-Bee (Chalicodoma muraria Fabr.)[1] — Prof. Justus Carrière's untimely death in 1894 left his valuable study of the embryology of the wall-bee incomplete. The notes and preparations of the Strasburg savant have been saved from oblivion by Dr. Otto Bürger, of Goettingen, and published in a fine quarto with thirteen excellent plates. The first part of the work, dealing with the formation of the germ-layers, is wholly the work of Carrière; the second part, by Bürger, is based on Carrière's preparations, notes, and sketches.

The work is of peculiar interest as the latest and most complete account of the embryonic development of a hymenopterous insect.

[1] Die Entwickelungsgeschichte der Mauerbiene (Chalicodoma muraria Fabr.) im Ei, v. Dr. Justus Carrière, herausgegeben und vollendet v. Dr. Otto Bürger. *Nova Acta, Abh. d. kaisl. Leop.-Carol. Akad. d. Naturforscher*, Bd. lxix (1897), Nr. 2, pp. 255–419, Taf. XIII–XXV.

Up to the present time the papers of Grassi (1884) and Bütschli (1870) on the development of the honeybee, contained nearly all our knowledge of hymenopterous embryology. The Hymenoptera are interesting as a highly specialized insect type, and the observations contained in Carrière's and Bürger's monograph are valuable because they enable us to appreciate more fully the peculiarities in the development of the more generalized insect orders (Apterygota, Dermaptera, Orthoptera, Odonata, Hemiptera, etc.). It also appears that certain problems, such as the origin of the germ layers, can be studied, as Carrière and Bürger show, to greater advantage in the bee than in any other insects hitherto investigated, because the embryo always remains on the ventral surface of the egg, and is never longer than the egg, *i.e.*, its posterior end neither curls over to the dorsal surface of the yolk as in Coleoptera, Diptera, etc., nor becomes imbedded in the yolk as in Hemiptera and certain Orthoptera. Other advantages of a technical character are the liquid yolk, which is easily sectioned, the thinness of the shell (chorion), and the large size of the egg. These advantages have enabled Carrière and Bürger to make an accurate study of the formation of the germ-layers. Their conclusions are essentially the same as those published by Heider and Wheeler in their studies of Coleoptera (*Hydrophilus* and *Doryphora*). The entoderm arises from two widely separated regions of the blastoderm, one at the anterior, the other at the posterior end of the blastodermic groove which gives rise to the mesoderm. The anterior entoderm rudiment sends back a pair of cellular, band-like prolongations under the mesoderm, while the posterior rudiment sends a similar pair forward. The prolongations of corresponding sides meet and then envelop the yolk by spreading dorsoventrally. During this process the mesoderm is constricted off from the blastoderm in the mid-ventral line, and the stomodæal and proctodæal invaginations form, respectively, over the anterior and posterior entoderm rudiments. The formation of the stomodæum and proctodæum is so closely associated with the origin of the two entoderm rudiments that one investigator, Heymons, has boldly denied the existence of an entodermal germ-layer in insects. Heymons derives the whole alimentary tract from the ectoderm (!). Bürger, however, very justly dissents from this view. He shows that the entoderm arises from the *undifferentiated* blastoderm, and that the stomodæal and proctodæal invaginations arise from the superficial layer of blastodermic cells, the only layer that can properly be called ectoderm.

There are many interesting new facts in the portion of the paper devoted to a description of the organs arising from the different germ-layers. Carrière discovered a pair of minute evanescent appendages on the first brain (protocerebral) segment, and another pair on the third brain (tritocerebral) segment. Bürger confirms the accounts of preceding writers who claim that the antennæ arise from the second brain (deutocerebral) segment. Three pairs of oral appendages and three pairs of thoracic appendages are formed as in other insects, the latter notwithstanding the fact that the bee has an apodal larva. The thoracic appendages, however, soon flatten out, and Bürger finds that their hypodermal cell-layer thickens and becomes the imaginal disks, which, in the larva, are the rudiments of the legs of the imaginal bee. This interesting observation should be brought to the notice of those investigators who regard the gonapophyses of insects as dyshomologous with ambulatory legs, for the reason that the gonapophyses develop from larval structures resembling imaginal disks (Heymons). Bürger claims that he was unable to find rudiments of abdominal appendages on more than the first to fourth segments. His figures 28 and 35, however, show them on all the abdominal segments as in many insects more primitive than the bee. The pairs on the eighth, ninth, and tenth segments are peculiarly distinct and are evidently the rudiments of the gonapophyses (ovipositor). Bürger nowhere mentions these structures.

Another valuable observation made by Bürger is the presence in the embryo of the imaginal disks of the wings. Weismann and Graber claimed to have found these in the embryos of the blowfly, but their accounts are far from being satisfactory. The wing-disks of the bee arise as a pair of hypodermal thickenings with subjacent accumulations of mesoderm cells lateral to the leg disks in the meso- and meta-thoracic segments. They are beautifully shown in Bürger's Fig. 173. The labrum arises as a pair of discrete appendages in front of the stomodæum. These ultimately fuse in the middle line.

The origin of the tracheæ, spinning glands, tentorium, and flexor mandibulæ are described in detail. The tentorium is formed from two pairs of ectodermal invaginations resembling tracheal pits in the mandibular and second maxillary segments. The flexores mandibularum arise from a similar pair of invaginations in the first maxillary segment. The spinning glands are derived from a pair of invaginations immediately behind the second maxillary segment. The Malpighian vessels arise, as Carrière has shown in an earlier paper,

before or during the invagination of the proctodæum, as two pairs of depressions in the ectoderm of the anal segment.

Bürger describes the formation of the midgut, or mesenteron, in detail. The vitellophags left in the yolk when the segmentation cells are migrating to the surface to form the blastoderm, in the later stages of development arrange themselves on the surface of the yolk as a continuous epithelium immediately inside the entoderm. This vitellophag layer, however, forms no portion of the definitive midgut wall, but disintegrates towards the close of embryonic life, just as the scattered vitellophags disintegrate in other insects.

Bürger's account of the nervous system of the Chalicodoma embryo is mainly valuable as a confirmation of the observations of Heider, Wheeler, and Viallanes on other insects. Carrière and Bürger regard the frontal ganglion as the first segment of the brain, and the labrum as its pair of appendages. Their interpretation of the remaining head segments is the same as that of the above-mentioned authors. The ventral nerve chord is derived from neuroblasts similar to those found by Wheeler in Doryphora. The ganglionic cells budded off from the neuroblasts are not in regular rows as in the Orthoptera (Xiphidium, *e.g.*). The account of the origin of the Mittelstrang is unsatisfactory. Bürger agrees with preceding writers in deriving the ganglia of the sympathetic nervous system from the dorsal wall of the stomodæum. The "ganglia allata" which Heymons discovered in Forficula arising from a pair of invaginations near the base of the maxillæ and subsequently moving around and uniting on the dorsal surface of the stomodæum, are probably not ganglia at all, if certain large structures found by Bürger in corresponding positions in the bee should prove to be homologous with the bodies observed by Heymons.

The development of the body-cavity (schizocœle) is traced by Bürger, together with the portions of the walls of the cœlomic sacs that give rise to the heart, pericardial septum, pericardial fat-body, the main mass of the corpus adiposum, the ventral and dorso-ventral musculature. The heart is formed from two rows of cells (cardioblasts), which move towards each other around the yolk and finally unite to form a tube in the mid-dorsal line. The deutocerebral is the only head segment that contains a pair of mesoblastic somites with distinct cœlomic cavities.

Carrière finds the first traces of the reproductive organs in embryos with the full number of segments and the appendages beginning to bud out. They appear as large cells in the walls of the mesoblastic

somites of the third, fourth, and fifth abdominal segments. These cells, which seem to be restricted to the dorsal wall of their respective somites, subsequently collect about a common center to form on either side a small oval body, — the ovary or testis. The vasa deferentia and oviducts arise from the mesoderm. The former terminate in the tenth, the latter in the seventh abdominal segment, in both cases in terminal ampullæ as described by Wheeler for Xiphidium. A thickening of the hypodermis over the terminal ampullæ represents the rudiment of the ectodermal portions of the reproductive organs (ductus ejaculatorius and vagina).

The embryonic envelopes of the Hymenoptera promise to yield interesting results when carefully investigated. In the Phytophaga the envelopes are complete and typical, as shown by Graber in *Hylotoma berberidis*. In the other Hymenoptera hitherto studied only one envelope, the amnion, is formed. Carrière shows that it arises in the wall-bee from the peripheral portion of the blastoderm and persists only a short time. The exact mode of its obliteration is not clearly figured or described. By the time of hatching it has almost completely disappeared. Bürger claims that embryos of *Polistes gallica*, at least in the later stages, agree with Chalicodoma in possessing only a single embryonic envelope, and that this also disappears before the hatching of the larva.

WILLIAM MORTON WHEELER.

Tumors and Germ-Layers. — Since tissue differentiation in organisms has come to occupy so large a place in the attention of biologists, the general subject of tumors has assumed a biological interest that is but little less than its medical interest.

A recent paper by Dr. D. Montgomery, with a note by Dr. L. F. Barker,[1] dealing with a case of teratoma, contains so much of interest that it deserves to be more widely known to biologists than it is likely to become through the pages of a medical journal. The tumor was taken from the peritoneal cavity of a girl twelve years old. It was of the solid variety, *i.e.*, it was not a single large cyst, but was a mass of tissue with a great number of small cysts scattered throughout its substance. Its weight was two pounds. It was situated on the right side of the abdomen, and was attached to the ascending

[1] A Teratoma of the Abdominal Cavity, by Dougless W. Montgomery, M.D., with a Note on Dr. D. W. Montgomery's Case of Teratoma, by Lewellys F. Barker, M.D. *The Journ. of Experimental Medicine*, vol. iii (May, 1898), No. 3, pp. 259–292.

colon throughout nearly its entire length, as well as to the adjacent peritoneum. According to Dr. W. F. McNutt, who performed the operation, the abdominal veins were dilated, but the tumor cleaved out easily and apparently completely. No large vessels were encountered during the removal beyond "such as run in brittle adhesions," though the peritoneal surface, from which the growth was removed, was left raw and bleeding.

The tumor "contained tissues and portions of organs corresponding in embryonic origin to all the germinal layers. Corresponding to the epiblast there were skin with cutaneous organs and appendages, central nervous system, peripheral nerves, and the rudiments of eye structure.

"The hypoblast was represented by mucous glands, tubes, and cysts, with epithelial lining and surrounded by smooth muscle. The mesoblastic tissues consisted of bone, cartilage, white fibrous tissue, yellow elastic tissue, mucoid connective tissue, adipose tissue, smooth muscle fiber, and blood vessels."

The nervous tissue was in large quantity, but no ganglionic cells were made out with certainty. Of the eye only portions of the pigmented layer of the retina, and possibly parts of the sclera, were found; but the former were so distinct and characteristic that both observers agree in considering error of identification as impossible. Highly significant concerning this tissue is the fact that "similar polygonal pigmented cells are to be seen irregularly distributed through the sections, sometimes apparently in solid portions of the tissues, sometimes lining small irregular slit-like spaces, and in one instance lining a space which is continuous with the cavity lined by ependymal epithelium, which probably corresponds to brain ventricle."

The blood in the vessels had all the characteristics of adult blood. No nucleated red cells were found. No trace of a heart was present.

After the operation the patient seemed to do well for a time, but in about a month it was found that the tumor was growing again, and it was removed a second time. The recurrent growth did not come away whole as did the first, as it was softer, more friable, and involved the peritoneum both more widely and more intimately than did the first. Like the original, "it contained tissues from all three germ layers. Indeed, all the structures met with in the original tumor could be found in various parts of the tissue removed at the second operation."

The authors discuss at some length the various theories concerning the origin of dermoid tumors, and both reach the conclusion that the *fœtus in fœtu* theory of Meckel explains most satisfactorily the present case. Biologically considered, some of the facts presented are very difficult to understand, even on this theory; *e.g.*, the widely distributed condition of the eye tissue and the recurrence of the entire tumor.

Dr. Montgomery assumes that some fragments of the original growth must have remained behind after the first operation, despite the fact that such did not seem to be the case; and that these fragments contained representatives of all the tissues found in the tumor.

W. E. R.

A New Journal of Parasitology. — The attention of naturalists was attracted last year by the announcement that the publication of a new journal devoted to the study of parasites would be entered upon in 1898 by Prof. Raphael Blanchard, of Paris, whose contributions to helminthology have been among the most valuable of recent years. And the belief was freely expressed that the journal would be successful from the start, and would take a high place in the periodical literature of science. The appearance of two numbers of about 180 pages each afford complete justification for this belief, and call for more than a passing notice.

The *Archives de Parasitologie* is to be a quarterly devoted, as the preface says, "to the study of (all) those organisms which are capable of causing disease in man and in the animals." Its scope, in consequence, is decidedly extensive, and deals with parasitology in the broadest sense rather than with helminthology merely. The numbers already issued present articles on bacteria, protozoa, worms, and arthropods, as well as on methods and apparatus, while mycology is also proclaimed to be within its sphere. On reading the prologue of Professor Blanchard one is forced to pause, and wonders whether after all such a field is not too wide to keep a circle of special readers interested; whether mycology and bacteriology, which have their own journals also, appeal in their special development to workers in zoology; and, finally, whether bacteriology in all its wondrous blossoming will not usurp the place of other topics; and yet the perusal of the numbers shows a remarkable balance of interest and influence. Nevertheless, here is an evident danger.

The contents of the numbers at hand deserve more specific mention as indicating clearly the character of the periodical. First should

certainly be mentioned the beautiful tribute to that "Altmeister der Helminthologie," Rudolph Leuckart, whose photograph opens the second part; and the verdict that, famed as he was by his researches, the greatest power of the man was displayed as a teacher, will be shared by his students in all lands to whom to-day even the mention of his name comes as an inspiration. Among the score or more of scientific contributions it is almost invidious to attempt a choice, and some of the shortest can hardly be passed without mention. Of most general interest are perhaps Artault's splendid investigation on the flora and fauna of the pulmonary cavities and Brault's diseases of tropical lands. Legrain's well-illustrated article on parasitic diseases of Algeria will be read with peculiar interest by the physician, while those who have spent weary hours wrestling with the dry bones of systematic confusion will hail with delight such articles as Shipley's revision of the Linguatulidæ and Stiles and Hassall's inventory of the Fasciolidæ. Railliet and Marotel's article on the pancreatic fluke, which is the first accurate account of this species, a discussion of phagocytic organs in ascarids by Nasonov, whose figures are valuable aids to the comprehension of this newly emphasized feature of nematode anatomy, and Verdun and Iversenc's note on cysticerci of the cerebral ventricles will each interest the zoologist while appealing most strongly to workers in particular lines. The latter article calls for especial mention by virtue of its admirable summation of recorded cases of this type.

Perhaps the most characteristic feature of all the articles is the evident desire, successfully realized in most cases, to treat subjects from the standpoint of the specialist and yet to interpret them in the broadest way possible. This is manifest also in the editorial notes, as witnessed in the discussion of vicissitudes of helminthological nomenclature, where a gentle but just rebuke is administered with all the delicate and proverbial courtesy of a Frenchman.

Following the original articles, of which the bulk of each number is made up, are several pages of notes, and a list of reprints received closes the part. This list is evidently destined to become a valuable quarterly summary of contributions to parasitology convenient of reference, since the arrangement is topical and praiseworthy in that the references are full and precise.

In general appearance the *Archives* demonstrates the expressed resolve of the founder "to neglect nothing to make the typography and illustrations irreproachable." The paper used is of fine quality, the type clear and pleasing to the eye, and the text-figures, which are

not sparingly employed, are of the best. The single plate thus far published is well executed, but to an American eye the prominence accorded the name of the publishers savors rather too much of an advertisement. The journal is, however, on the whole one of which both the founder and the scientific world may well be proud, and for which all will join in wishing that abundant success for the future which the present numbers promise.

HENRY B. WARD.

The Weigert Methods. — Prof. C. J. Herrick has published in the *New York State Hospital's Bulletin* for October, 1897, a report upon a series of experiments with the Weigert staining methods. The author has in contemplation a study of the components of the cranial nerves in bony fishes, and as this rests largely on the myelination of the nerves, a careful study of the Weigert methods has preceded it. The results, satisfactory as well as unsatisfactory, are given for the different fixing reagents, mordants, etc., and form a body of valuable suggestions for those who propose applying these methods to the lower vertebrates.

BOTANY.

Britton and Brown's Flora.[1] — As a rule, large undertakings proceed slowly, and although Professor Britton's friends had known for some years that he was at work on a new manual of the general region covered by the familiar work of Dr. Gray, most of them were surprised when confronted with the first volume of the book in 1896. The prompt appearance of the second volume, and the publication of the third and concluding volume within less than two years from the appearance of the first, are no less surprising than was the early commencement of the work, and its industrious authors are to be congratulated on their energy and the perfection of their plans.

It was a happy thought, that of placing not only a description but a figure of each species in the hands of students at a price not too high for the rather cramped purse of the average botanist, and doing

[1] *An Illustrated Flora of the Northern United States, Canada, and the British Possessions, from Newfoundland to the Parallel of the Southern Boundary of Virginia, and from the Atlantic Ocean Westward to the 102d Meridian.* By Nathaniel Lord Britton, Ph.D., and Hon. Addison Brown. In three volumes. New York, Charles Scribner's Sons. Vol. iii, Apocynaceæ to Compositæ, 1898, 4°, pp. xiv + 588, many figures in the text.

it has led to the illustration of 4162 species, belonging to 1103 genera and 177 families, by figures drawn from nature for the work. No less commendable is the effort to bring together in the index all of the popular names employed for the wild plants of the region covered — a task in which the scholarship of Judge Brown has proved no less serviceable than the botanical acumen of Dr. Britton in the management of the systematic details.

As a general thing, floras of regions that have been so long and so well studied as the eastern United States are compends of species which have been published previously in monographs of genera, accounts of special collections, and the like, their chief value consisting in the skillful elimination of insufficiently grounded species and the provision of keys of all grades, by which rapid and accurate diagnosis is made of those which are maintained. The *Illustrated Flora* claims conservatism in the admission of new species, but admits that "it is better to err in illustrating too many forms, rather than in giving too few"; and besides splitting composite species into forms which really conservative botanists are disposed to unite, it contains, especially in the third volume, a considerable number of original descriptions which will render its possession indispensable to future students of the American flora, whether they agree with its authors or not. Especial attention should be called to the dozen or more asters characterized as new species, not to mention the very large number of forms in the same genus which are given new varietal names, as a result of the preliminary revision of this difficult genus by Professor Burgess.

No descriptive manual of recent times is likely to be more diversely judged by the botanical public than the one under review. Its aims are excellent. Its keys and figures usually give a Latin name for any individual specimen, and the non-professional user, by following the naïve suggestion to use the index of common names in connection with the figures, is likely to make surprising and no doubt gratifying progress in the acquisition of this sort of information. But he is likely, if he progress to the comparison of the characters of his specimens with the descriptive text, to find some puzzling interlocking of the species that have received names. He is sure, also, to find that the Latin names used are not those that he will find in common use in other botanical, horticultural, and pharmaceutical works that he is likely to consult, if his studies are technical, nor in the usual works relating to the flora of the eastern United States, if he be a botanist or botanically inclined. If already familiar enough

with the last-mentioned works to have acquired the habit of opening them readily to any desired family or genus of plants, he will also be annoyed because the sequence of families in the present work is not at all the same. These differences come from an effort to follow the sequence of groups of the great German treatise of Engler and Prantl, on the families of plants, and the nomenclature rules of the Botanical Club of the American Association for the Advancement of Science, as exemplified in the check list of the plants of eastern North America, published by its committee in 1893–94. Less objection will be made to the first than to the second of these changes from American custom, and, notwithstanding the difficulties of the undertaking, the authors of the book have been reasonably consistent in carrying out their ideas, so that it is going to prove an important factor in fixing the names preferred by the Neo-American school upon our plants; whether wisely or unwisely, it may be left for the future to show.

T.

Detmer and Moor's Physiology.[1] — The guide to practical laboratory work in a comparatively new field never comes amiss, and although several such guides in vegetable physiology are now in the hands of English-speaking teachers, this translation of Detmer's well-known *Praktikum* is a very welcome addition to their shelves. Nature study is frequently spoken of as a means of training the power of observation, but it is useful even to a greater extent as an educational factor, because it is an experimental study if properly pursued. Experimentation is largely a matter of personal ingenuity, like mechanical invention. In any direction, its foundations are laid by a small number of specially gifted men. But just as soon as their methods are understood, they may be applied by hundreds of other students to the solving of problems that are everywhere awaiting solution. Every book which, like Detmer's, outlines the general field of study and indicates the simplest apparatus and methods for attacking it, paves the way for the elaboration of refinements in the investigation of special subjects.

The topics treated are: the physiology of nutrition, and the physiology of growth and movements resulting from irritability. For these

[1] *Practical Plant Physiology.* An introduction to original research for students and teachers of natural science, medicine, agriculture, and forestry. By Dr. W. Detmer. Translated from the second German edition by S. A. Moor. 8°, pp. xix + 555. 184 illustrations. London, Swan, Sonnenschein & Co. New York, The Macmillan Company.

subjects, it is really an outline text-book, with directions for the practical demonstration of the facts which in an ordinary text-book stand simply as statements on authority. The student who has worked through it should be an expert and well-trained physiologist; if not, he may ask himself if he had not better turn his attention to other things. Unfortunately, the usual college elective does not allow time for making expert specialists, and the teacher who can devote but a short time to experimental physiology is likely to prefer one of the smaller and cheaper books for the direct guidance of his classes, though he cannot afford to allow them to do their work without constant reference to the more comprehensive handbooks, foremost among which stands this of Detmer.

T.

Minnesota Botanical Studies. — In January, 1894, *Bulletin No. 9 of the Geological and Natural History Survey of Minnesota* was begun as an occasional serial, the intention being to page the parts consecutively until a volume should be completed. In March, 1898, the twelfth part was issued, completing the first volume of the *Bulletin.* This volume contains fifty separate articles by twenty authors, dealing with a wide range of subjects, by no means confined to Minnesota geographically. It is illustrated by eighty-one plates or maps, and, as completed with its very full index, contains 1093 pages octavo. While unlimited praise cannot be bestowed on all of its contents, it is a valuable addition to the shelves of any botanical library which may be fortunate enough to possess it; but one cannot help wondering at the liberality of the State Survey of Minnesota in allowing so much matter wholly foreign to the usual purposes of such surveys to be published and distributed at the expense of the state.

T.

Edible Fungi. — To the already rather copious literature intended to facilitate discrimination between edible and poisonous fungi, Professor Farlow has recently added a small conservatively written article, which has been reissued in pamphlet form from the *Yearbook of the Department of Agriculture* for 1897.[1] Limiting himself to a very few species of both classes, which are accurately and yet tersely described in language which should be readily understood by any person of intelligence, the writer states a few rules which "should not be neglected by the beginner" in the following words: 1. Avoid

[1] Farlow, W. G. Some Edible and Poisonous Fungi. Washington, Government Printing Office, 1898. United States Department of Agriculture, Division of Vegetable Physiology and Pathology, *Bull. No. 15*. 18 pp., 10 pls., 8°.

fungi when in the button or unexpanded stage; also, those in which the flesh has begun to decay, even if only slightly. 2. Avoid all fungi which have stalks with a swollen base surrounded by a sac-like or scaly envelope, especially if the gills are white. 3. Avoid fungi having a milky juice, unless the milk is reddish. 4. Avoid fungi in which the cap or pileus is thin in proportion to the gills, and in which the gills are nearly all of equal length, especially if the pileus is bright colored. 5. Avoid all tube-bearing fungi in which the flesh changes color when cut or broken, or where the mouths of the tubes are reddish, and in the case of other tube-bearing fungi experiment with caution. 6. Fungi which have a sort of spider-web or flocculent ring round the upper part of the stalk should in general be avoided. To these simple rules, the observance of which should prevent any case of serious poisoning, though, as the writer states, it need not be assumed that a fungus is poisonous when it is merely indigestible, in consequence of the way in which it is cooked, numerous exceptions are possible in favor of aberrant edible forms; but they are for experts, and the caution is worth heeding that "the beginner is, of course, under the necessity of following the rules implicitly."

Another recent contribution to the same subject, and likewise an outcome of work done in the first instance in connection with the United States Department of Agriculture, is Dr. Taylor's *Student's Handbook*,[1] illustrated by a considerable number of plates, some of them colored, and containing recipes for preparing and cooking fungi, in addition to the customary keys and descriptions. T.

Natal Plants. — Under this title J. Medley Wood and Maurice S. Evans have begun the publication of a series of descriptions and figures, in quarto, of the indigenous plants of Natal, with notes on their distribution, economic value, native names, etc. The first part, recently issued, contains fifty figures and descriptions.

Professor Weed's Seed-Travellers[2] is one of the helpful little books designed to aid in nature-study, and if, as the author recommends, it is used in connection with observations upon the specimens it describes it can be made very useful. The illustrations, about half

[1] Taylor, Thomas. *Student's Handbook of Mushrooms of America, Edible and Poisonous.* Washington, A. R. Taylor, 1897, 1898. 8°.

[2] *Seed-Travellers, Studies of the Methods of Dispersal of Various Common Seeds.* By Clarence Moores Weed. Boston, Ginn & Co., 1898. 12°, pp. 53, ff. 36.

of which are original, probably have not come out quite as was intended, and it is not evident that most of them really serve the purpose of the book ; but two or three of them are very attractive.

The Grasses of Uruguay. — Prof. J. Archevalato has recently brought together in a large volume [1] the results of his study of this important group. The first twenty-eight pages are devoted to an organographic account of the grasses, some thirty-five pages are given to a discussion of what is called applied agrostology, and a very full index to both popular and scientific names occupies twenty-two pages. The remainder of the work consists of rather full descriptions of the species. Unfortunately, keys, which would have made the work more usable, have not been provided either for genera or species.

T.

The Metropolitan Parks of Boston. — The last report written by Charles Eliot,[2] which is very tastefully gotten up, contains much of interest to the landscape architect, many plates which ingeniously indicate by means of folding duplicate foregrounds the means of improving existing features, and an analysis of the commoner types of woodland scenery, which, with the accompanying reproductions of photographs, will also be of use to persons interested in plant communities as viewed by the œcologist.

T.

Botanical Notes. — The vegetation of the white sands east of the San Andreas Mountains, in southern New Mexico, on which Miss Eastwood had previously published, forms the subject of a note in the issue of *Science* of July 29, by Cockerell and Garcia, from which it appears that on these sands, 97% of the substance of which is gypsum (calcium sulphate), a considerable flora flourishes, some of the constituents of which appear to have undergone considerable modification in connection with their environment.

Professor Hitchcock, who for some years has been studying the weeds of Kansas, publishes, as *Bulletin No. 80 of the Experiment Station of the Kansas State Agricultural College*, a paper on their distribution. For the 209 species listed, the geographical distribution

[1] *Las Gramineas Uruguayas*. Montevideo, 1898. 4°, pp. 553, ff. 13 + lxxiii.

[2] *Vegetation and Scenery in the Metropolitan Reservations of Boston*. A forestry report written by Charles Eliot and presented to the Metropolitan Park Commission, Feb. 15, 1897, by Olmsted, Olmsted & Eliot, Landscape Architects. Lamson, Wolffe & Co., Boston, New York, and London, 1898.

of all within the limits of Kansas is indicated to the eye by the use of reduced maps, and for a number of species the range within the limits of the United States is shown in the same manner, so far as it was known.

The plants of the southeastern United States figured in Smith and Abbot's *Insects of Georgia*, a century ago, form the subject of a synonymic note by Britten in *The Journal of Botany* for August.

The collection, preparation, and shipment of exotic drugs forms the subject of a paper by Professor Planchon in a recent number of the *Bulletin de la Société Languedocienne de Géographie.*

As a result of several years' study, Burgerstein concludes that most of the pomaceous genera are separable by anatomical characters derivable from their secondary wood. His paper on the subject [1] includes a series of analytical keys based on the more reliable characters.

An interesting popular article by James Epps, Jr., on the cacao plant and its utilization, illustrated by a number of half-tone plates, appears in the *Proceedings and Transactions of the Croyden Microscopical and Natural History Club* for 1897, recently issued.

The Onagraceæ of Kansas form the subject of a paper by Prof. A. S. Hitchcock in a recent number of *Le Monde des Plantes.* Thirty-six species are enumerated, and for each is given a small map showing its distribution in the United States, and another indicating the counties of Kansas from which it has been reported.

The genus Bartonia is increased by Dr. Robinson, in the *Botanical Gazette* for July, by the addition of *B. iodandra*, a new species from Newfoundland, first collected in 1894 by Robinson and Schrenk, and more recently found some 200 miles from the original locality by Waghorne.

The eighth part of Professor Engler's "Beiträge zur Kenntnis der Aracæ," in Heft 3 of the *Botanische Jahrbücher* for the current year, consists in a revision of the genus Anthurium, in which a goodly number of species are described for the first time.

In his twelfth annual report as botanist of the Nebraska State Board of Agriculture, distributed in July as a reprint from the *Annual Report of the Board* for 1897, Professor Bessey gives a brief definition of the botanical regions of that state, as understood by Pound and Clements in their *Phytogeography of Nebraska*, and dis-

[1] Burgerstein, Alfred. Xylotomisch-systematische Studien über die Gattungen der Pomaceen. *Jahresberichte des k. k. zweiten Staatsgymnasiums im II. Gemeindebezirke in Wien, 1898.* Wien, 1898.

cusses at some length the forage problem as presented in each of the four principal regions recognized by them.

The grasses and forage plants and the forage conditions of the eastern Rocky Mountain region are discussed by Professor Williams in *Bulletin No. 12 of the Division of Agrostology of the United States Department of Agriculture.* The paper is illustrated by thirty figures.

Prometheus, No. 442, contains a readable article by Carus Sterne on Kohlenlager and Sumpfwälder, in connection with which should be read the paper on a fossil cypress swamp in Maryland, published by Arthur Bibbins in the August number of *The Plant World*, which is illustrated by an excellent reproduction of a photograph showing the stumps of the ancient forest as exposed at a beach on the Chesapeake.

Recent American papers on the archegoniates are: "The Gametophyte of *Botrychium virginianum*," by E. C. Jeffrey;[1] "On the Leaf and Sporocarp of Pilularia," by Duncan S. Johnson;[2] and "Conditions for the Germination of the Spores of Bryophytes and Pteridophytes," by Fred De Forest Heald.[3]

An interesting feature of *The Fern Bulletin*, a little quarterly published at Binghamton, N. Y., is promised in a series of papers by Mr. Alvah A. Eaton on the genus Equisetum with reference to the North American species, which it is proposed to illustrate with actual specimens of each species and variety treated.

Just's Botanischer Jahresbericht, which heretofore has been issued in rather large fascicles, some three years after the appearance of the papers of which it gives abstracts, begins its twenty-fourth year (containing the literature of 1896) in smaller sections, and, from the prompt appearance of the first of these, it is to be hoped that in future the useful abstracts which this indispensable handbook contains may all be available for reference by the end of the second year after the original papers have been published.

The Annals of Scottish Natural History for July announces that Miss Anne H. Cruickshank has given £15,000 for the formation and maintenance of a botanic garden in Old Aberdeen. The administration is placed in the hands of a board of six trustees, who are to use the proceeds of the gift to further botanical teaching and study in the University of Aberdeen, while permitting the public to visit the garden under suitable regulations. It is understood that Professor Trail will be the director of the garden.

[1] *University of Toronto Studies.* Biological Series, No. 1, 1898.
[2] *Botanical Gazette*, July, 1898. [3] *Ibid.*

A popular article on the plants of Australia, by Mr. Adcock, is printed in the *Journal of the Royal Horticultural Society* for July, which also contains an interesting article by E. F. im Thurn, entitled "Sketches of Wild Orchids in Guiana."

The Journal of the National Science Club for February last contains a short but interesting article on the Order Diapensiaceæ, by Margaret F. Boynton, illustrated by two plates of floral dissections and diagrams.

The New England Antennarias, long treated as representing a single very polymorphous species, form the subject of a paper by M. L. Fernald, published in the current volume of the *Proceedings of the Boston Society of Natural History*, in which six species and seven varieties are characterized.

The comparative anatomy of certain genera of the Cycadaceæ forms the subject of a paper, illustrated by one double plate, published in the July number of the botanical *Journal of the Linnean Society*, by W. C. Worsdell.

The Castilleias of the group of *C. parviflora* form the subject of a paper by M. L. Fernald in *Erythea* for May, in which a synoptical revision is given of those of northwestern America.

Calochortus clavatus, one of the best of the Mariposa lilies for garden purposes, is well figured in *Curtis's Botanical Magazine* for July.

Under the title "Floral Structure of Some Gramineæ," Lueders describes aberrant spikelets of *Panicum proliferum* and *Andropogon furcatus* in vol. xi of the *Transactions of the Wisconsin Academy*, recently issued.

A paper on the structure and development of Dendroceras, a genus of liverworts, is published by Prof. D. H. Campbell in the *Journal of the Linnean Society* for July.

West Indian Characeæ, collected by T. B. Blow, form the subject of a short paper by Henry Graves in the July number of the *Journal of the Linnean Society*, in which two Charas and three Nitellas are listed. One of the latter, *N. dictyosperma*, is described and figured as new.

To the earlier lists of Wisconsin parasitic fungi, by Trelease and Davis, Dr. Davis, in the eleventh volume of the *Transactions of the Wisconsin Academy*, adds a considerable number, among which is one new species, *Entyloma castaliæ* Holw., on Nymphæa and Nuphar.

PALEONTOLOGY.

Fossil Cephalopods in the British Museum. — Lists of published material in museums are a valuable aid to investigators, and such lists are welcomed by museum men. The present list[1] comprises about nine hundred and fifty entries of types and figured specimens, presenting a graphic testimonial to the richness of the collections of cephalopods in the British Museum. The list is arranged alphabetically by genera ; in the index the arrangement is alphabetical by species, so that any given form is readily found. This is an excellent system for such a list. Frequent critical notes give special information in regard to specimens or published figures. Specimens are listed under their names, as originally described in the publications cited. It would have been desirable in addition to have included in brackets, or otherwise, the current generic names where they differ.

A defect in the list is the fact that types are not indicated as such. A type is the specimen or specimens from which a new species or genus was described, and as such should be distinguished from other published material. "Orthocera" and "Orthoceras" are listed separately as if they were two genera. Both names are the same word, the difference being insufficient for generic distinction. By the system adopted, the same species in a genus become separated in an artificial way, as in the case of "*Orthocera politum*" and "*Orthoceras politum.*" The species might have been listed under Orthoceras, indicating the original spelling where necessary. A few specimens are included, which, as the author says, have been erroneously referred to the Cephalopods, such as "*Helicoceras elegans* . . . a Gastropod." A recent *Nautilus pompilius* is also listed. In a catalogue of fossil Cephalopods, it would have been better to have put these associated forms at the end of the list, rather than in the body of the text.

R. T. J.

PETROGRAPHY AND MINERALOGY.

Basic Rocks in Italy. — Near Ivrea, a small town on the Dora Baltea in Italy, is a small area of basic eruptive rocks that have recently been studied by Van Horn.[2] The principal type is a norite.

[1] Crick, G. C. List of Types and Figured Specimens of Fossil Cephalopods in the British Museum (Natural History). London, 1898.

[2] *Min. u. Petrog. Mitth.*, Bd. xvii.

This passes by addition of quartz into a rock called by the author a quartz-hypersthene-diorite, and by addition of brown hornblende into a type called a hornblende-gabbro. The norite consists of basic plagioclases, hypersthene, diallage, brown and green hornblende, biotite, a few accessory minerals, and decomposition products of the plagioclase. The diallage and hypersthene are often in parallel intergrowths. In the quartz-hypersthene-diorite biotite is more common than it is in the norite. Brown hornblende is absent. In the hornblende-gabbro brown hornblende is more abundant than the pyroxenes. It is the characteristic constituent. Its prismatic angle is 124° 18′ and its density 3.217–3.222. The mineral is pleochroic with $\mathfrak{a}$ = yellow; $\mathfrak{b}$ = reddish brown; $\mathfrak{c}$ = yellowish brown. The extinction $\mathfrak{c} \wedge c$ varies between 14° 30′ and 15° 30′. A portion separated from the rock powder yielded when analyzed:

SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	H_2O	Total
39.58	14.91	4.01	10.67	tr.	13.06	11.76	2.87	.62	2.79 =	100.27

This gives in calculation very nearly the formula $(HKNa)_2$ $(MgFeCa)_4$ $(AlFe)_2$ Si_4O_{16}, or in its generalized form $R'_2\, R''_4\, R'''_2$ $(SiO_4)_4$, a formula unusual for amphibole. The author suggests that there may be a group of amphiboles that are orthosilicates, though the greater number of them are unquestionable metasilicates. The three rock types described grade into each other by almost imperceptible changes, the gabbro and the diorite being peripheral forms of the norite. Analyses of the three rocks follow:

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	H_2O	
Horn.-gabbro	39.84	.08	19.71	7.73	8.89	tr.	7.33	13.52	1.59	.53	tr.	.86 =	100.08
Uorite . .	49.95	.69	19.17	4.72	6.71	tr.	5.03	9.61	3.13	.74	tr	.09 =	99.84
Qu.-Hyper.-diorite . .	56.45	tr.	20.15	4.36	5.00	tr.	2.66	6.59	2.95	1.00	.24	1.61 =	101.02

The Rocks Associated with the Iron Ores in Switzerland. — Among the rocks associated with the iron ores in Canton Grisons, Switzerland, are several that are extremely interesting, according to Bodmer-Beder.[1] Among them are a porphyritic quartz-diorite, auralite-porphyrite, and a quartz-biotite porphyry. The latter has a micro-granitic groundmass and large phenocrysts of orthoclase, and smaller ones of oligoclase, quartz, and biotite. The groundmass consists of quartz and plagioclase, muscovite, zoisite, sericite, sphene, epidote, apatite, sillimanite, garnet, magnetite, hornblende, biotite, and secondary substances. Some of the quartz phenocrysts are crossed by

[1] *Neues Jahrb. f. Min.*, etc., Bd. xi, p. 217.

twinning lamellæ produced along slipping planes parallel to the rhombohedron. In addition to the minerals above mentioned there are also present in the rock in small quantity allanite, anatase, brookite, ilmenite, zircon, an inclusive of sodalite in one of the quartz phenocrysts, some fluorite and barite. The analysis following shows the presence also of some other substances not detected by the microscope.

SiO_2	Al_2O_3	Fe_2O_3	FeO	Fe	K_2O	Na_2O	CaO	MgO	BaO	Cu	Pb	SO_3	S	BO_2O_3	TiO_2	P_2O_5	Cl	F	H_2O	
68.89	14.05	2.18	1.43	.23	4.30	4.56	2.15	.83	.58	.03	.04	.30	.26	.38	.23	.03	.07	.05	.41	= 101.00

The ores of the district are mainly magnetite, mixed with small quantities of pyrite, hematite, limonite, chalcopyrite, malachite, and cuprite, and associated with tourmaline, calcite, apatite, and the fresh and altered constituents of diorite. They are thought to be differentiation products of the diorite, while the associated minerals are the result of later dynamic and pneumatolytic processes.

Swiss Schists. — In the course of a study of the geology of the Val di' Mortirolo in the Alps, Salomon[1] met with several rocks of sufficient interest to merit detailed investigation. These are adamellites, hornblende-diorites, potassium and sodium gneisses, and micaschists, exhibiting in a very clear manner the effects of mountain-making forces. These effects are expressed in different ways, according to the nature of the rock acted upon, either as bending, as crushing, or in chemical transformations. The adamellite has yielded a "microcline-augen-gneiss," and the hornblende-diorite a clinozoisite-albite-amphibolite. After examining critically the effect of the mountain-making forces in deforming the mineral components of the rocks studied, the author concludes that the bending of great (rock) masses without fracture hardly ever occurs, but that fractureless bending and deformation with fracture may unite in different proportions, depending upon the mineral composition of the rock effected, the severity of the pressure and the duration of its action, to produce rock-bending. A special form of fractureless deformation is effected through the chemical transformation of minerals and the consequent transportation of their material particle by particle. This view of dynamical metamorphism is not very different from that of Van Hise, as discussed in the article referred to below.

[1] *Neues Jahrb. f. Min.*, etc., Bd. xi, p. 355.

Nomenclature of Contact Rocks.[1] — Salomon, in his discussion of the geological relations of the granite massifs of the southern Alps lying between Piedmont and the boundary of Hungary, finds occasion to refer briefly to many contact rocks. The confusion in the nomenclature of this most interesting of rock-groups leads him to suggest a simplification in the method of naming them. The less altered phases in the outermost zones of contact action he would call by the names of the original rocks from which they were formed, adding the word "contact" as a prefix, as "contact-sandstone"; for the more highly metamorphosed phases, he would use "hornfels," with a suffix indicating its mineral character. Thus we would have a "hornfels-gneiss," a "hornfels-micaschist," etc.. The names edolite, astite, aviolite, and seebenite are proposed for combinations of mica and feldspar, mica and andalusite, mica and cordierite, and cordierite and feldspar.

A large number of brief descriptions of the granite of the massifs, and of the metamorphic rocks surrounding them, are scattered through the article, which is geological rather than petrographical.

Petrographical Notes. — Basalt occurs south of New-Lars and north of Kasbek in the Caucasus. Hibsch[2] reports the rock from both localities to contain phenocrysts of quartz and feldspar in a basaltic matrix composed largely of glass. The quartz phenocrysts are surrounded by aureoles of augite. The phenocryst plagioclases consist of rounded acid nuclei of the composition AbAn enclosed in peripheral zones of a more basic feldspar, Ab_2An_3, of the same composition as the plagioclases in the groundmass. Many augite crystals, also, are built around nuclei of hypersthene. Hibsch explains the phenomena as due to the presence in the basalt of foreign quartz, acid feldspar, and hypersthene grains obtained from an andesite.

Cohen[3] reports the existence of a tourmaline-hornfels in the contact zone around the granite of Sea Point in the Cape States.

The subject of metamorphism and the metamorphic rocks is treated critically by Van Hise[4] in an essay that discusses the physico-chemical and the dynamic-mass, and molecular principles involved in the production of highly crystallized rock types from glassy and clastic forms. The nature of the essay prevents its successful abstraction, as it is itself the abstract of a fuller treatise on the same subject.

[1] *Min. u. Petrog. Mitth.*, Bd. xvii, p. 143.
[2] *Ibid.*, p. 285. [3] *Ibid.*, p. 287.
[4] *Bull. Geol. Soc. Amer.*, vol. ix, p. 269.

Meteorites.[1] — The writer believes that the iron meteorites, known as siderites, are of the same nature as the small specks of iron that occur in nearly all the stony meteorites; that they represent the product of a slower crystallization of the meteoric mass under specially favorable, and therefore rarely occurring, conditions; that this explains the fact that stony meteorites are of much more frequent occurrence than siderites. Moreover, he believes that a meteor containing these iron concretions is more subject to rupture by explosion on reaching our atmosphere, the nodules forming points of weakness; and that therefore the iron nodules are generally freed from their stony matrix before falling, and may arrive at the earth's surface at a distance from the lighter constituents. The Estherville fall is quoted as a good example of such a case. He further points out that meteorites with a deeply pitted surface are coarsely crystalline, and contain relatively large troilite nodules, the pits being probably due to the tearing away of portions of the mass along the easy fracture planes of the large crystal individuals, whereas in the masses with finer texture such fracture would be less likely, and a smooth surface would be formed.

The siderites secured by Mr. Ward[2] while in Australia in 1896 are from the following localities: (1) 200 miles southeast of Roebourne in northwest Australia, weight 191½ lbs.; (2) 10 miles south of Ballinoo, West Australia, weight 93 lbs.; (3) three miles north of Mungindi P. O., New South Wales, two masses of 62 and 51 lbs.; (4) Mooranoppin, West Australia, weight 2½ lbs. All four irons are octahedral in structure, No. 3 being remarkable for the ease with which Widmanstätten etching figures of great clearness and beauty may be developed.

The siderite described by Preston was found in the prairie seven miles south of San Angelo, Tom Green County, Texas. Its weight was 194 lbs., and the structure noticeably octahedral, a broken surface exhibiting large cleavage faces. It showed a few troilite nodules and veins of a lustrous graphitic-looking mineral. Its composition, together with that of three of the Australian irons, is shown in the following table of analyses by Mariner & Hoskins, Chicago, Ill.:

[1] Preston, H. L. On Iron Meteorites as Nodular Structures in Stony Meteorites. *Am. Journ. Sci.*, vol. clv (1898), p. 62.

[2] Ward, H. A. Four New Australian Meteorites. *Ibid.*, p. 135. Preston, H. L. San Angelo Meteorite. *Ibid.*, p. 269.

	(1) Roebourne.	(2) Ballinoo.	(3) Mungindi.	San Angelo.
Fe	90.914	89.909	90.307	91.958
Ni	8.330	8.850	8.230	7.860
Co	0.590	0.740	1.360	trace
P	0.156	0.501	0.093	0.099
C	trace	trace	0.010	trace
Si	0.010	trace?	trace?	0.011
S	trace	trace	trace	0.032
Mn	trace?	—	—	trace?
Cu	—	trace	—	0.040
	100.00	100.00	100.00	100.00
Specific Gravity	7.78	7.8	7.4	7.7

Mineralogical Notes. — Pratt[1] describes the following minerals from North Carolina: *Cyanite*, from the farm of Tiel Young, Yancey County, in large, grass-green crystals showing the forms: *c*, 001; *b*, 010; *a*, 100; *m*, 110; *M*, 110; *Q*, 120; *t*, 520; the last new for the species. Pale-green cyanite has been found at a number of localities in the region named, as well as at Graves Mt., Ga., where it is accompanied by rutile. *Zircon*, from New Stirling, Iredell County, in large crystals of pyramidal habit showing the forms: *a*, 100; *m*, 110; *p*, 111; *v*, 221; *x*, 311. *Anorthite*, from Buck Creek, Clay County, forming with olivine a mass of troctolite rock, the crystals of feldspar varying in size up to an inch and a half long and three-quarters of an inch broad. Its specific gravity is 2.699 to 2.744, and its composition almost that of a pure anorthite, as shown by the appended analysis.

Farrington[2] describes crystals of datolite from Guanajuato, Mexico, associated with calcite and quartz. The crystals are small, transparent, colorless, faces fairly bright and sharp; 17 forms were determined, none of them new to the species. The crystals assume three types of habit, one of which closely simulates that of datolite from Bergen Hill, described by Dana, being tabular parallel to *x*, 102. One crystal showed a merohedrism simulating inclined-faced hemihedrism.

[1] Pratt, J. H. Mineralogical Notes on Cyanite, Zircon, and Anorthite from North Carolina. *Am. Journ. Sci.*, vol. clv (1898), p. 126.

[2] Farrington, O. C. Datolite from Guanajuato. *Ibid.*, p. 285.

SCIENTIFIC NEWS.

Fresh-water investigation in Switzerland is in charge of a "Limnological Commission" of the Swiss "Naturforschende Gesellschaft." This Commission was under the presidency of Prof. F. A. Forel, but for a number of years of late the position has been occupied by Prof. F. Zschokke, of the University of Basel. At present the Commission is engaged principally in an exhaustive examination of the Vierwaldstättersee. This work is in charge of a special committee of which also Professor Zschokke is chairman. The investigations have been carried on for three years, and are in full progress at present; they include work along physical, chemical, botanical, and zoological lines. The physical report has been published, and two zoological papers — upon the plankton and the Mollusca — are ready for the press. It is hoped that the entire project will be completed in ten years. The results are published in the *Berichten der Naturforschenden Gesellschaft zu Luzern.* There is a finance committee that secures the funds needed for the prosecution of the work by subscriptions from the authorities, societies, and individuals interested in the locality. Lake Zürich is also being investigated by the city of Zürich, in conjunction with the University and its associated polytechnic schools. The zoological part of the work is in charge of Dr. G. Heuscher, and the botanical side is attended to by Prof. C. Schröter. The Limnological Commission also has an interest in these explorations. The individual work of Prof. F. A. Forel upon Genfersee and that of the International Commission on Bodensee should also be mentioned.

Profs. E. L. Mark and W. M. Davis, of Harvard, and Henry F. Osborn, of Columbia, are spending their sabbatical year in Europe.

Osbert Salvin, the well-known ornithologist, and co-editor with Frederic Godman of the *Biologia Centrali Americana*, died near Haslemere, England, at the age of 63. He was a graduate of Cambridge, made three trips to Central America, and was for several years editor of the ornithological journal, *The Ibis*. He was author, either alone or with an associate, of about 125 papers.

The University of California has been presented by the Alaskan Commercial Company of San Francisco with the large and valuable

collections which the company has been accumulating for many years. The ethnological portion of the collection is especially rich, and doubtless one of the best in existence. Th[illegible] collection also embraces fossil remains of mammoth, and many skins and mounted specimens of birds and mammals and invertebrates of the Alaskan region.

Recent Appointments: Miss Agnes May Claypole, of Wellesley, assistant in histology and comparative physiology in Cornell University. — Dr. F. E. Clements, instructor in botany in the University of Nebraska. — Dr. W. McM. Woodworth has been appointed assistant in charge of the Museum of Comparative Zoology at Cambridge.

Appointments to fellowships: University of Nebraska, Albert [illegible]. Lewis and Charles C. Morrison in zoology, Cassius A. Fisher in geology, Albert T. Bell and Cora F. Smith in botany. — Johns Hopkins University, Dr. Gilman A. Drew, Bruce fellow in biology.

The following appointments to fellowships have been made by Harvard University: Parker fellowship for non-resident study, Frank Watts Bancroft, zoology. — Morgan fellowships, Amadeus William Grabau, paleontology; Edward Charles Jeffrey, botany.

The following appointments have been made at the University of Illinois: Mr. C. W. Young, B.S., assistant in botany; Mr. Wallace Craig, B.S., assistant in the State Laboratory of Natural History at Illinois Biological Station, Havana, Ill.; Mr. E. B. Forbes, B.S., field entomologist of the State Laboratory of Natural History; Dr. J. P. Hylan, assistant professor of psychology; Dr. C. A. Kofoid, assistant professor of zoology. — Mr. C. F. Hottes, M.S., assistant in botany, goes to Bonn and Leipzig for botanical study.

Recent deaths: Dr. Theodor Eimer, professor of zoology in the University of Tübingen, and a well-known advocate of Neo-Lamarckian views, May 29. — C. W. A. Hermann, mineralogist, in New York, June 21, aged 97.

PUBLICATIONS RECEIVED.

BARNES, C. R. Plant Life, Considered with Special Reference to Form and Function. New York, Henry Holt & Co., 1898. x + 428 pp., 8vo, 415 figures. $1.12.

FRIČ, ANT. Studien im Gebiete d. böhmischen Kreideformation. Palaeontologische Untersuchungen d. einzelnen Schichten. VI. Die Chlomeker Schichten. Prag, Fr. Rivnâc, 1897. 83 pp., 124 figures. From *Arch. f. Naturw. Landesforschung von Böhmen.* Bd. x, No. 4. — FRIČ, ANT., and VÁVRA, V. Untersuchungen ü. d. Fauna der Gewässer Böhmens. III. Untersuchungen zweier Böhmerwaldseen, des Schwarzen f. d. Teufelssees. Prag, Fr. Rivnâc, 1897. 73 pp., 33 figures. From *Arch. f. Naturw. Landesforschung von Böhmen.* Bd. x, No. 3. — HILL, R. T. The Geological History of the Isthmus of Panama and Portions of Costa Rica. Based upon a reconnoissance made for Alexander Agassiz, with special determinations by W. H. Dall, R. M. Bagg, T. W. Vaughan, J. E. Wolff, H. W. Turner, and Ahe Sjögren. *Bull. Museum Comp. Zoöl.* Vol. xxviii, No. 5, 134 pp., 19 plates, June. — KAIN, S. W. List of Recorded Earthquakes in New Brunswick. Compiled from Published Works and from Private Information. From *Bull. Nat. Hist. Soc. of N. B.* Vol. xvi, 1898.

Annales d. l. Société Belge de Microscopie. Tome xxii, Fasc. 2. — *Annotationes Zoologicæ Japonenses.* Vol. ii, Pt. ii, 1898. — *Geographical Journal.* Vol. xii, No. 1, July. *Johns Hopkins Hospital Reports.* Vol. vii, No. 3. Report in Pathology, Chas. R. Bardeen. A review of the pathology of superficial burns, etc. — *La Nuova Notarisia.* Ser. ix, July. — *Michigan State Agricultural College.* Report of the Botanical Department. *Michigan State Agricultural College, Experiment Station.* Elementary Science Bulletins 1–4. W. J. Beal, Study of Beans and Peas before and after Sprouting. Study of Wheat and Buckwheat before and after Sprouting. Study of the Seeds of Timothy and Red Clover before and after Sprouting. Observations on the Leaves of Clovers at Different Times of Day.

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VARIATION VERSUS HEREDITY.[1]

HENRY S. WILLIAMS.

In proposing to discuss this subject I have no new examples either of variation or heredity to describe, nor any new evidence to bring forward, with which to confirm established beliefs regarding these two well-known and important factors of biology. But I would like to call attention to a point of view from which variation, which we are accustomed to regard as a kind of accidental and abnormal performance of organisms, looms up into a prominence second to no other phenomenon of life, and stands out as the fundamental and distinctive characteristic of living beings. From this point of view, natural selection in all its different forms, the direct and indirect effects of environment, and other processes which, according to the orthodox view, are believed to be agencies in promoting evolution, appear but subsidiary steps in the acquirement of heredity, and are concerned only in checking evolution and in bringing the organism into a state of subjection to the mechanical laws of the physical environment in which they live.

[1] Read before the Section F, Zoology, American Association for the Advancement of Science, Boston Meeting, August, 1898.

It is taken for granted that readers are familiar with the orthodox, or common working hypothesis, of modern naturalists in regard to these matters; but, in order that we may be thinking alike, let me mention a few particulars to which special attention is directed.

(*A*) It is assumed to be the accepted belief that *organisms acquire their distinctive characters by the processes of natural growth and development.*

(*B*) That it is the accepted belief that those characters which in a particular organism are *like* the characters of its parents and ancestors are to be explained on the hypothesis of *heredity, i.e., that organisms naturally reproduce offspring like themselves.*

(*C*) That it is the accepted belief that the characters which are *unlike* those of the parents are explained on the hypothesis of *variation, i.e., that organisms differ slightly or vary naturally from their immediate ancestors.*

It will be noticed that the term *organisms* in the second statement refers to the *parents* in the case; in the third statement it refers to the *developing offspring.* I understand this to be the accepted view, *i.e.*, that it is assumed that the *causative factor* determining the hereditary reproduction of *like* characters is associated with the *parent;* and, on the other hand, that the causative factor of *diversity* is associated with the *individual varying* in response to diversity in the conditions under which it develops. Or, to put this whole idea definitely as a separate proposition,

(*D*) It is the orthodox hypothesis, regarding this question, that *an organism arising under conditions entirely similar to those of its immediate ancestors, would not vary from them, but would develop in perfect facsimile to them;* and, therefore, that *variation is incident to heterogeneity of environment.*

Is all this true? Or is not the very converse of it true? In opening the discussion of this question, let me refer to the opinions of the founders of the evolution theory on this point.

In the year 1861 Darwin wrote to Thomas Davidson: "My greatest trouble is, not being able to weigh the direct effects

of the long-continued action of changed conditions of life, without any selection, with the action of selection or mere accidental (so to speak) variability. I oscillate much on this head, but generally return to my belief that the direct action can have played an extremely small part in producing all the numberless and beautiful adaptations in every living creature" (*Life and Letters*, vol. ii, p. 369).

Fifteen years later, in 1876, in a letter to Moritz Wagner, is found the following statement: "In my opinion the greatest error which I have committed has been not allowing sufficient weight to the direct action of environment, *i.e.*, food, climate, etc., independently of natural selection" (*Life and Letters*, vol. iii, p. 159); and in the following year, 1877, he wrote Malchior Neumayr: "There can now be no doubt that species may become modified through the direct action of the environment" (vol. iii, p. 232). The above quotations show where Darwin located the cause of variation, both when writing the *Origin* and in the later period of his life.

Again, in a letter to Lyell, in 1860, we find this statement: "Talking of 'Natural Selection,' if I had to commence *de novo*, I would have used 'natural preservation'" (vol. ii, p. 346). And, in 1863, to Asa Gray, Darwin wrote: "I have sometimes almost wished that Lyell had pronounced against me. When I say 'me' I only mean *change of species by descent*. That seems to me the turning point. Personally, of course, I care much about Natural Selection; but that seems to me utterly unimportant compared to the question of Creation or Modification" (vol. ii, p. 371).

These letters show where Darwin placed the emphasis in his life work. *Modification of species by descent* is the great discovery, and natural selection and direct effects of environment he believed to be the chief factors in bringing about this modification; but they were really secondary to the great fact of simple evolution, or the modification of organisms in the course of descent.

His letters leave no doubt that what he meant by "Natural Selection" was "Natural Preservation"; the "Survival," as Spencer put it, of characters which have already arisen in

ancestors by variation, and, after being tried by experience, are found favorable to the organism possessing them, and are, therefore, reproduced in their offspring. Cope and Henslow and others have called attention to this unmistakable meaning of natural selection. And Wallace, in 1866, criticised Darwin's use of the term "Natural Selection" by saying, "Nature . . . does not so much select special varieties as exterminate the most unfavorable ones."

On the other hand, the recognition of the view that variation is the prime factor of evolution, was evidently in the minds of both Lyell and Asa Gray, and was one of the chief causes of their hesitation, at first, to accept in full Darwin's theory of evolution. But, as a theory to explain the *origin of species*, Darwin was right, for the fundamental characteristic of species is not variation, but the *persistent reproduction of like characters*, and natural selection and the direct and indirect effects of environment are the most potent agencies discovered in determining this persistent uniformity of reproduction. But producing uniformity is not evolution.

The founders of the modern theory of evolution, while they were united as to the modification of species by descent, and in assuming that natural selection and kindred agencies were conspicuous factors in the general process of evolution, were not uniform in the assignment of the part played by these factors. Nevertheless, in the expressions of philosophical opinion regarding these points, above quoted, we find they were aware that the immediate effect of natural selection, etc., was in the direction of making characters hereditary, in "preserving" them in the reproductive sequence of the race. With the preconception, and as I believe misconception, that heredity is the essential characteristic of living organisms, it was necessary to believe that the organism could not, *of itself*, evolve into something different; hence the natural conclusion that variation must be *induced* by external agencies, and natural selection, etc., are these agencies which stimulate and promote variation, and at the same time check and hinder it. Herein lies one of the great inconsistencies of the orthodox theory.

The point of view suggested in this paper corrects some of these inconsistencies.

One of the difficulties, which seems to be removed by the new point of view, is seen by noting the simple phenomenon which takes place in any concrete case of natural selection.

First: In any particular case of selection it is necessary *that some character*, which has appeared for the first time in the course of the growth of a particular organism, *should reappear in its offspring*. The character is said to be "transmitted"; it "survives"; it is "preserved" in the offspring. In order to be thus "preserved," it ceases to be a divergent and variable element in individual growth, and becomes a regular or hereditary character in the descendants.

So far as the character itself is concerned it was produced without any precedent before it was found to be either profitable or unprofitable, and in being preserved it is simply reproduced. So far as the principle of modification is concerned, the offspring which reproduces the variable character of its parent is *less* variable than its parent, and if natural selection causes the preservation of the character, to that extent it is effective in checking evolution.

Secondly: It is to be observed *that that which takes place in the varying individual differs in degree, not in kind, from the ordinary processes of growth, or individual development.* Variation is not some peculiar mode of action of an organism, but it is the same process by which the individual builds up its hereditary characters. In the ordinary growth, as the organism develops from the germ to the adult each step of progress in development is, for the cells undergoing the development, a process of variation from the behavior of the parent cells from which they arose. So long as the varying does not exceed the varying of previous organisms, the process is called individual development, and is purely hereditary. Whenever the varying results in producing structure not hitherto produced, it is evolution.

On the assumption that this hereditary process of reproduction is a necessary and fundamental function of organisms, it is necessary to assume that some new law comes into opera-

tion where development ends, and variation, the first step in evolution, begins. Whereas, in fact, it is difficult even to imagine how the closest possible scrutiny of the growing individual could detect the place where normal development ends and variation begins.

Variation, in any concrete case, is simply the development of the individual in some different way, or to a degree beyond the attainment of its parents; but it is, nevertheless, normal constructive development. The whole secret of individual development lies in the fact that in the reproduction of growing cells, the daughter cells are slightly different from the parent cells, greater uniformity occurring in each mass of the same tissue or organ, but absolute uniformity nowhere. The multiplication of similar cells in growth, and their gradual modification in the construction of dissimilar tissues and organs in development, are phenomena no less diverse than is the hereditary process of reproduction of individuals from the variational production of specific differences. Variation is exhibited whenever an organic body produces another body dissimilar to itself, whether that body be a cell or an individual. Heredity is exhibited in both cases in the phenomenon of reproducing that which has already appeared.

Thirdly: Let us take another view of the subject and note *the relation which variation and heredity bear to experience.* In any concrete case of a growing organism the construction of a character according to heredity implies the experience of having previously constructed such a character, on the part of the parent, which is conceived of as the controlling cause of the process. Variation, on the other hand, is, when it first occurs, spontaneous, in so far as that means previous to experience. So far as the individual, or the race to which it belongs, is concerned, the varying act is an original act; it does not depend upon specific experience. Heredity is, therefore, of the nature of habit or memory, and implies experience. Variation is, in its intrinsic nature, original and genetic.

Selection is one of the steps in the acquirement of heredity, and thus the "origin of species" by natural selection is the acquiring of a regular, or hereditary, method of development

for each series, or race of organisms, breeding and developing together under like conditions.

If varying brings about modifications which are beneficial, then that which promotes varying must be an advantage. But in order to originate a species, varying is checked, and it is only as natural selection checks, transmits, and preserves, *less variably*, the characters acquired by variation that the origin of species results.

Thus we discover that the application of this hereditary principle to organisms, as a fundamental characteristic of living processes, makes it necessary to assume that evolution does not work in harmony with it; but only by checking, antagonizing, and violating heredity is any progress attained.

On the other hand, on the view that variation is the ultimate principle of all vital phenomena and is operative (as it is known to be) prior to experience, evolution becomes the fullest expression of life, and heredity and relative uniformity of reproduction the most natural expressions of the economical adjustment of living organisms to the limitations of environment. Evolution, in other words, takes place, naturally, as fast as the construction of organization and adjustment to environment furnish the possible medium for its expression. On this hypothesis evolution becomes as natural and universal a process for organic bodies as gravitation is for physical bodies.

Fourthly: According to the current philosophy of evolution, struggle for existence is assumed to be a most important factor in determining the course of "selection," or "preservation," by which advance is made. This struggle for existence is assumed to operate in the way of overcoming competitors for the same sources of good; and fitness to survive is measured by the capacity to grow big.

This theory, that measure of success is amount of food an organism can assimilate, that growing fat is evidence of fitness to survive, is consistent with the belief that repetition of the characters of ancestors, or heredity, is the primary law of organisms; and it is this philosophy which would lessen competition as a means of promoting progress.

But we have only to observe the natural course of the history of every organism to see that the setting up of antagonisms is not only the fundamental but the necessary law of organisms.

The most strenuous struggle which occurs in the life of any organism is that which separates it from its closest ancestor, its most intimate helper, the source, at the time of the separation, of all its good. No struggle with competitors, afterwards, equals in proportionate expenditure of energy this one. In the higher animals the term *labor* has been applied to it, because all other labor is but a faint imitation of it.

This greatest and universal struggle is the means of breaking with ancestry and setting up independence. So far as the immediate parent is concerned, the amount of energy expended in preparing for, caring for, and building up this offspring, which must necessarily increase and not diminish the total difficulties of living, is in excess of any other kind of energy put forth by the organism. And as to the offspring itself, the separation from the parent is a departure from almost total dependence and inactivity into increasing struggle and labor.

Thus in this process, which we are apt to associate most intimately with the law of heredity, is seen in operation this principle of doing otherwise, of departure from the bonds of heredity, of variation from the immediately preceding course of action of the individual performing the acts. It seems to us, as we ascend a mountain, as if the rough things in the path were the real hindrances to progress, but the fact is that the great work of a climber is always spent in overcoming the gravitation which would keep him at the bottom, and adjustment to the rocks on the way of his path is an insignificant part of his task. So it is not so much the local impediments of environment as the inertia of heredity which has to be overcome in each step of progress of evolution.

Malthus's theory rests on the assumption that there are more applicants than there are goods; but whether this be true or not, it is certainly true that the greatest kind of human success we know of, and the most conspicuous examples of success, are those cases in which hitherto useless, because unused, sources of good are appropriated and their value realized, and thus the

way to new resources is opened. On the other hand, it is reliance upon ancestry, personal inactivity, failure to struggle, refusal to put forth the energy possessed, that constitute the curses of all organisms; and it is such evils that natural selection is constantly eliminating in the struggle for existence and the survival of the fittest. The first sign of headship and leadership and fitness to survive is a declaration of independence from the bonds of heredity. The place of greatest resistance, of hardest struggle, must be overcome before real progress can be made, and it is success there which is the first sign of fitness to survive and to perpetuate the race.

The very essence of virility, as of all evolution, consists in doing otherwise, — in varying from the past, in transgressing tradition, not violating but surpassing the laws of heredity. And the measure of success in such struggle is not accumulation of resources, but increase of productiveness. The most successful is the one which gets most result out of the resources at hand, and such success survives. But this is the law of variation, not heredity.

Fifthly: In order further to test the correctness of this hypothesis, it is important to examine the real *meaning of this phenomenon of variability.* What is the real fact to which attention is called by saying a species or an organism varies? Is there only a rearrangement of unchanging atoms? Is there something new originated? And what is the result of varying?

Darwin's theory of pangenesis, and the various other attempts, up to the most elaborate of all, Weismann's theory of germ plasm, which conceive of some sort of physical basis for the differences which arise in organic processes, are an indication of a belief that evolution does not originate anything new, that it merely seems to do so; and that organisms, like inorganic bodies, are substantially immutable. This mechanical theory provides for two categories, — things and acts, — into which objective phenomena may be distributed: things whose chief distinction is that they are posited and extended in space, and acts posited and extended in time. We cannot observe anything as absolutely inactive, nor can we observe any real act separated from some form of thing. But in imagination

the physicist abstracts the thing-in-itself, or the substance of things, as matter, which in its ultimate nature, as atoms, is unchangeable — immutable. In like manner, he abstracts from experience the substantial basis of observed actions and calls it energy. Thus in the working hypothesis of physics, the substantial basis of particular acts is energy, exactly as the substantial basis of particular things is matter. But the physicist finds no place in this hypothesis for any variation in the ultimate kind, amount, or constitution of these two substantial bases of experience. All differences in phenomena are, to this theory, different arrangements of immutable units.

The application of this hypothesis, of the immutability of the essence of things, to the phenomena of living organisms requires us to assume that there are some kinds of ultimate immutable units back of organisms, which necessarily behave uniformly, except as they may be diverted by the action of some force from outside. Thus, I suppose, has arisen the almost universal belief that the uniform behavior of organic bodies, which we define by the term *heredity*, is a necessary and fundamental characteristic of organic units, just as inertia is a characteristic of inorganic bodies. The final outcome of this view is the assumption of the existence of separate and immutable units for every divergent phenomenon of organisms. Darwin evidently adopted some such view, and I do not see that the followers of Darwin have escaped this fundamental conception in elaborating the general evolution hypothesis. But the first step toward correcting it was taken when the idea of immutability was dissociated from the organic species.

Cuvier was the last of the great naturalists to maintain the immutability of species. It was the recognition of the intrinsic mutability of the organic species that made a rational theory of evolution possible, and it is my sincere conviction that a consistent theory of evolution cannot be built up which stops here. I cannot discover that there is any halting place. In order to explain the wonderful phenomena of organisms, the principle of mutability must be extended to the ultimate units of which every living body is composed. Not only the species, but the individual, the cell, the units which constitute the living

form of protoplasmic matter, must be conceived of as in a normal state of mutability.

That which makes an organic body to be vital, and distinguishes it from matter in an inorganic state, is this constant and incessant varying.

Recognizing this as the fundamental characteristic of living matter, it is very easy to conceive how varying will proceed constantly and in all directions, like a gas expanding, except when checked and guided by the impact and restraints of external conditions.

I have now stated briefly the meaning of the proposition that *variation, and not heredity, is the fundamental characteristic of the phenomena of organisms,* and a few of the arguments which recommend this view to consideration and acceptance as a working hypothesis for future investigation.

These arguments may be stated briefly as follows :

First : In any concrete case of natural selection, or similar processes, the actual result of selection is the retarding and checking of variation ; and the offspring necessarily evolves more slowly than its parent, in direct proportion to the efficacy of the natural selection.

Secondly: That the organic processes by which variation takes place in an organism differ from the ordinary process of development in individual growth only by passing beyond the limit reached by the ancestor; and hence variation is but a phase of the fundamental genetic process peculiar to living organisms.

Thirdly: That every act of variation is anterior to experience, and thus is necessarily original and genetic, whereas every hereditary act is necessarily secondary to, and the result of, experience, and that the law of heredity must, therefore, be acquired in the process of evolution, and is not fundamental.

Fourthly: That, as to struggle for existence, the most strenuous effort that is made (both by the parent and by the offspring) in the course of organic processes is that which produces antagonism of interests. On the part of the parent, it parts with that which has cost it the greatest expenditure of energy ; and on the part of the offspring, the result is the loss, in part or wholly, of the only source of its living up to the moment of the struggle.

Fifthly: That the orthodox view of the case is inconsistent, in so far as it recognizes mutability as applicable only to organic species, and clings to the idea of immutability of the more fundamental units of biology, *viz.*, the individual, the cell, and the protoplasmic states of matter.

These considerations bring us to a point of view in which heredity and variation hold a different relation to evolution than in the ordinary working hypothesis of biology.

If this point of view presents the facts in their true relations, we must seek for the immediate determining causes of variation, not in natural selection, nor in any of the environmental conditions, either direct or indirect, by which hereditary repetition is established, but in the phenomena of individual growth and development, and in the more fundamental processes of cell growth and metabolism.

NEW HAVEN, CONN.,
August 15, 1898.

A BASIS FOR A THEORY OF COLOR VISION.[1]

WILLIAM PATTEN, PH.D.

PART I.

THE physiologists and the psychologists have carefully studied and compared the sensations caused by ether waves of various lengths, and have attempted to explain how these manifold sensations of light and color are produced. But a satisfactory theory of color vision can never be worked out in this way, any more than a comparative study of the sensations produced by sticking different kinds of pins into the body will enable us to predict the internal sequence of events aroused by such treatment. To do that, the anatomist must first tell us what the internal mechanism is like. But he has told us very little about the retina. In fact, all that we know about its structure, either in man or in the lower animals, might be lost to science without seriously affecting the generally accepted theories of color vision. Any facts, therefore, that may possibly explain how different kinds of ether waves produce a differential response in nervous structures will be very welcome. The problem of color vision, like that of hearing, is primarily a mechanical one. We may be sure that since the stimulant that produces in us the sensation of light and color is a series of waves of definite length and frequency, the things responding to these movements must have a definite structure and position, whether they are molecules, or nervous plates, or bars, or fibrils; and their structure and position must determine the kind of waves to which they respond.

The conditions are in some respects similar to those in the ear, but they are different in so far as the cochlea possesses a

[1] This paper was read before the American Physiological Society at Ithaca in December, 1897. It appeared by title a year earlier on the programme of the Morphological Society, but, owing to lack of time, a five-minute abstract only was read.

series of fibres, or hairs, over which sweeps the whole gamut of sound waves, each wave length probably affecting one element only as it passes along the keyboard. In the eye, on the contrary, every point in the most sensitive part — that is, every cone — appears to possess within itself a mechanism similar to that in the whole cochlea, for it responds at the same time to almost any wave length from red to violet, or to many combinations of them.

It is, therefore, to the rods and cones that we must look for the solution of our problem. They are very small transparent bodies and apparently structureless. It is true that in Sir Isaac Newton's time there were supposed to be three sets of fibres in the retina, the stimulation of one set initiating mainly the sensation of red, another that of green, and the third that of blue. By combining these three sensations in various ways, it was thought that all the remaining color sensations could be produced, just as we can produce all the other spectral colors by mixing red, green, and blue light. Subsequently, various imaginary chemical compounds were substituted for the fibrils. But no evidence has been produced to show that these things exist. The physiologist "makes believe" these substances are present in the retina, but he is very careful not to say just how they should be distributed in order to produce the effects that actually are produced; or why one substance responds to one wave length more than to another; or how the single or combined responses are transmitted without confusion and loss of individuality to the cerebral centres. I believe that a reasonable answer can be given to these questions if we can only clear our minds of old traditions and look at the problem from a new standpoint.

A comparative study of the visual elements gives us this new point of departure, and we venture to offer a theory of color vision based on the fact that the rods and cones, or the parts corresponding to them in the lower animals, are not homogeneous, but fibrillated, and that in a number of invertebrates the fibrils are arranged according to their length in accurately graded series, and in such a position that they always stand at right angles to the rays of light that fall on

them. The ether waves thus vibrate across a series of fibrils of different lengths.

We assume that the length and position of a fibril determine the amount of its response to an ether wave of a given length, and as each visual cone contains a complete series of these fibrils, we may understand how each cone responds to the entire series of visible ether waves or to various combinations of them; and since the rods and cones vary in shape and in size in the retinæ of different animals, or even in different parts of the same retina, there should be a corresponding variation in the length and in the number of fibrils they contain, and consequently a corresponding variation in the powers of color vision.

I shall first describe the structure and arrangement of the retinal cells in some invertebrates, omitting, of course, many details that cannot be introduced into a paper of this character. Then, assuming that the human retinal cells have a similar structure, I shall try to show how we may explain many phenomena of color vision on that basis.

More than twelve years ago I described a series of what seemed to be nerve fibrils arranged with great regularity in the rods and retinal cells of mollusca and arthropods (*Mitth. aus Neapel*, 1886). Although from time to time I have confirmed and considerably extended my original observations, no other investigator appears to have made a serious attempt to do so. But indirectly the observations have received ample confirmation, since my description of the nerve endings in the retinal cells are in complete harmony with the best recent results obtained from the study of other organs by the methylen-blue and the gold-chloride methods.

We have not found these fibrils in the rods and cones of vertebrates, but there is no good reason to doubt their existence there, since, as I shall show elsewhere, the retinal cells in both vertebrates and invertebrates agree in many important details.

Whether these fibrils in the rods are nerve fibrils in the usually accepted meaning of the term need not detain us here. It will be sufficient for our purpose if we can show that these

sensory cells contain fibrils that may act as conductors or as resonators to certain kinds of movements.

The following is a very brief statement of the most important conclusions we have reached concerning the structure and arrangement of retinal cells.

(1) *Structure of a Retinal Cell.* — A typical retinal cell or retinophora, such as those found in molluscs and arthropods, although it has the outward appearance of an ordinary sensory cell, is in reality a double, or twin, cell. It consists of two nearly equal parts, readily distinguished by differences in optical properties; each part contains a nucleus and supports half of the rod (Fig. 1[1]). A large nerve fibre is attached to the base of the cell and there breaks up into a dense mass of fibrils that penetrate and surround the cell and the rod. Although there is no sharp demarcation between them, we are able to distinguish three sets of these fibrils. The first set consists of comparatively coarse fibrils running lengthwise of each retinophora between its two parts; they are often closely united to form a distinct axial bundle extending into the rod and sometimes beyond its outer end. The second set ramifies over the surface of the cells and the rods. Some of them appear to be independent intercellular nerve fibres not united with the large bundle attached to the base of the cell. The third set is found mainly in the rods, where they form what I have called a *retinidium*, which consists of a series of extremely delicate transverse fibrils that appear to unite the coarser axial and the superficial rod fibres with one another. These cross fibrils give the rods either a finely dotted or a striated appearance, according to the direction from which one looks at the fibrils.

Such a retinal cell, therefore, appears to contain a mass of fibrils which extend through the center of the cell into the rods, where they bend at right angles and become continuous with those on the peripheral layers. At the base of the cell all the fibrils are gathered together to form an axis cylinder, and after extending some distance, they separate and end freely.

(2) *Position of the Visual Rods.* — The rods may be upright, inverted, or, very rarely, horizontal, as in the ocelli of some

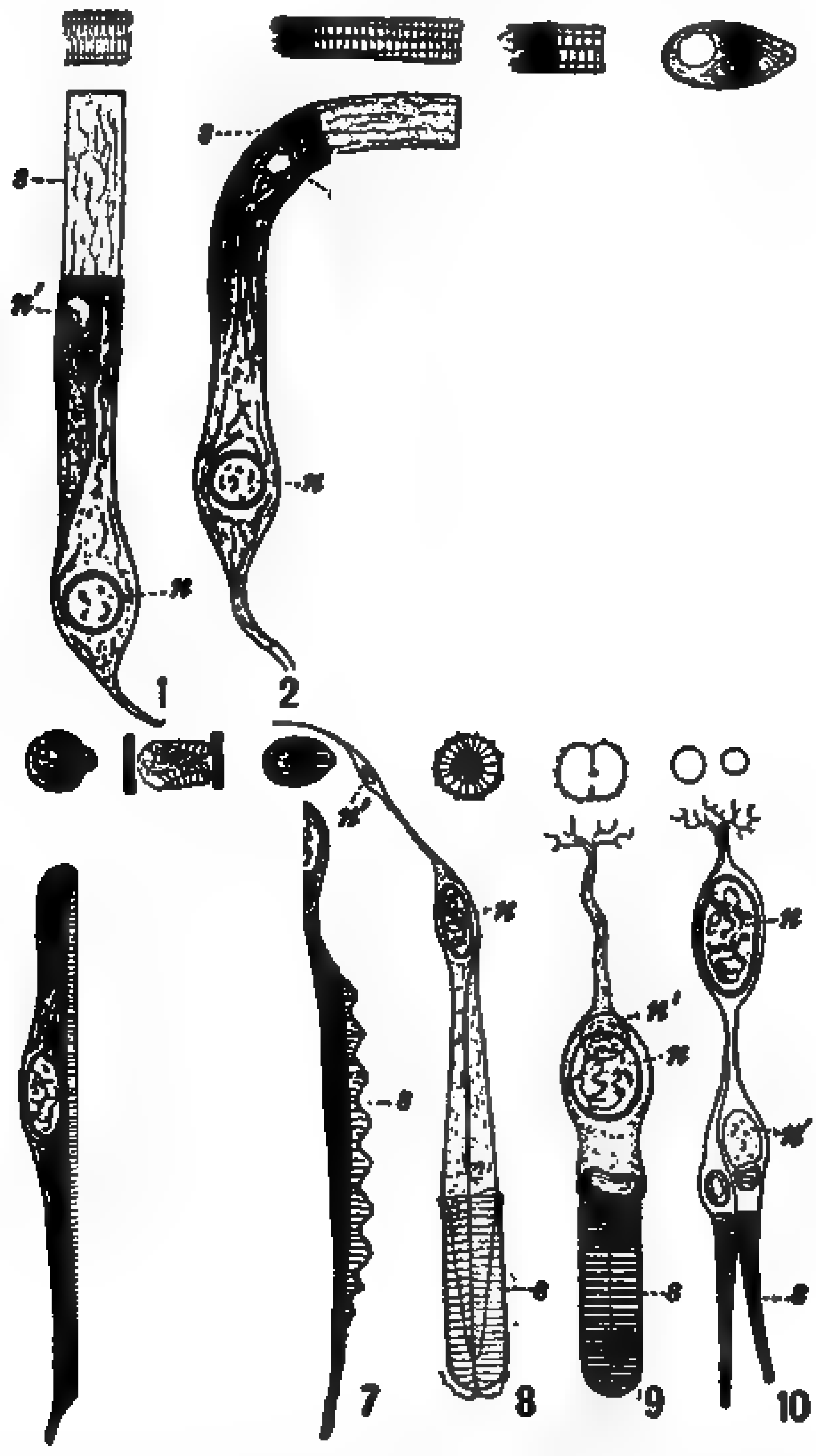

Fig. 1. — Various forms of retinophora, isolated by maceration and showing position and shape of retinal rods. Cross-sections of the rods are shown over each figure, the place where the section is taken being indicated by the letter *S*. 1, upright terminal rod from ocellus V of Acilius (see Fig. 2); 2, horizontal terminal rod from sides of ocellus II of Acilius (*cf.* Fig. 3); 3, a giant retinal cell with short horizontal rod from ocellus II; 4, retinal cell with lateral rod from compound eye of Limulus; 5, retinula cell from compound eye of Tabanus; 6, retinal cell from the ocellus of Lycosa; 7, retinula cell with serrated rod from the compound eye of Pinæus, 8, inverted retinal cell from the eye of Pecten; 9, rod cell from retina of an Amphibian (species of Diemyctylus), showing two nuclei, *n'* and *n*, and indications of division of rod into two parts with either a canal or fibre running through a part of the rod; 10, cone cell from same animal, showing double nature of the cell as well as of the cone. The body corresponding to the second nucleus lies at *n'*.

insects; or they may be terminal or lateral, as in either the simple or the compound eyes of arthropods. But in all cases, except the small horizontal rods of *Acilius*, the long axes of the rods are parallel to the rays of light falling on them, as shown in Fig. 1, where the light in each instance is supposed to come directly from above.

(3) *The Shape of the Rods in Cross-Section and the Arrangement of the Retinidial Fibrils.*— The shape of the rods in cross-section is a matter of great importance, because it usually indicates how the retinidial fibrils are arranged. The cross fibrils lie in superimposed planes, generally placed in one of the following positions: (*a*) When the rods are cylindrical, the cross fibrils radiate from the centre of each rod, like the bristles of a test-tube cleaner (Fig. 8, *A*, Pecten). (*b*) When the rods are quadrilateral in section, as in Acilius and Lycosa, all the cross fibrils in the same transverse plane are nearly parallel (Fig. 8, *B*, *C*, *D*). (*c*) When the rods are bound together in groups of from three to eight, as in the compound eyes of many arthropods (Tabanus, *E*, Bdellostoma, *F*, Dytiscus, *G*, Fig. 8), the angular relations of the cross fibrils will vary with the number of cells in the retinula. (*d*) In some crustacea (Penæus) the rods are serrated and dovetailed into one another in such a way that certain cross fibrils in a given transverse plane are parallel to one another, but at right angles to those in the planes above and below them (Figs. 1^7 and Fig. 8, *H*).

But whatever may be the position or shape of the rods, their retinidial fibrils always stand at right angles to the rays of light that fall on them. This is shown in Fig. 1, where all the retinal cells are seen in their natural positions. Over each figure is a cross-section of the rods, showing the direction of the retinidial fibrils. These figures, however, give only a very rough idea of the number and delicacy of the fibrils. The modifications of the shape and of the position of the rods that may occur without changing this arrangement of the fibrils are very curious and interesting, but they cannot be detailed here beyond what is given in the figures.

(4) *Position of the Retinidial Fibrils in Different Ocelli of the Same Animal.*— Where there are several pairs of ocelli in the

same animal, as in Acilius and in Lycosa (Figs. 4 and 5), the retinidial fibrils in one pair are nearly at right angles to those in two other pairs, so that the animal may be said to have its

FIG. 2. — Vertical section through ocellus III of Acilius.

retinidial fibrils arranged in the three planes of space, like the hairs in the semicircular canals of the vertebrate ear. But it is a curious fact that in Acilius the pair of ocelli marked No. VI — and in Lycosa the anterior median pair — do not have their retinidial fibrils arranged in parallel lines. The arrangement of the ocelli on the right side of the head of Acilius, as seen from

above, is shown in Fig. 4. One looks down into the boat-shaped retinas of ocelli I and III, the shape of which in cross-sections is well shown in Fig. 2. In these ocelli the flattened ends of the rods (shown on a larger scale in Fig. $1-^{1-8}$) are seen as short, nearly parallel lines, the retinidial fibrils, not represented in the figures, running at right angles to them. The median band of pigment and the double row of giant rods are indicated by heavy lines. The retina of ocellus V is seen end-

FIG. 3. — Section through ocellus V of Acilius.

wise, as though retina III were rotated 90° on its long axis and then stood on end, bringing the row of giant cells in a vertical position; see also Fig. 3. We therefore view the rods flatwise and lengthwise. Retinas II and IV are like those of eyes I and III, but smaller. They are placed so that the space between the two rows of giant cells lies in the plane of the paper, consequently we are looking at the giant rods lengthwise and edgewise.

In Lycosa the retinas I, II, and III show a similar orientation to the three planes of space. These three retinas are in every

way similar to each other except as to size. A single retinal cell is shown in side view in Fig. 1–6 and a section of the retina in Fig. 6; this section is cut through ocellus II (Fig. 5) vertical to the plane of the paper and at right angles to the zigzag lines of pigment. On the right side of Fig. 5 these cells are shown, on a somewhat larger scale, in the three positions they occupy in the corresponding ocelli. An enlarged section nearly parallel with the surface of ocellus II (Fig. 5) is shown in Fig. 7. On the right of this figure the section plane is deeper, show-

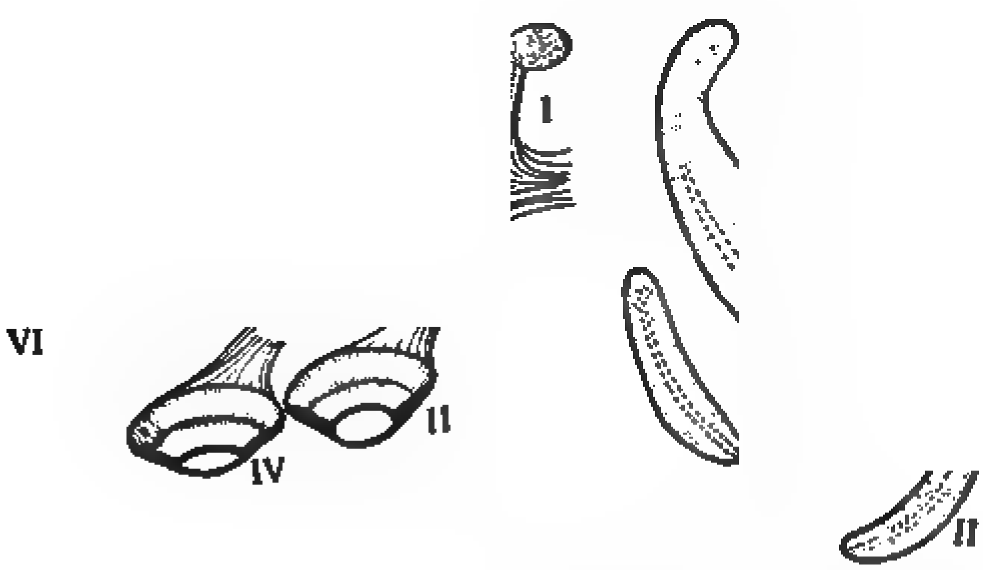

Fig. 4.—Diagram to show the arrangement of the rods in the ocelli of Acilius, and the way in which the fibrils of the optic ganglia resemble in arrangement those in the corresponding retinas.

ing the argentea and the ends of the rod cells. A comparison of these figures shows that the rods are arranged in zigzag rows, fenced off on either side by a band of pigment, and with a concave reflecting membrane beneath each row. The rods contain parallel fibrils (Fig. 7), and they are conical both in cross and in longitudinal section (Fig. 5, I[a] and II[a]). The rods in the centre of the retina are very small, gradually increasing in size towards the periphery. We have here, therefore, a most beautiful arrangement, one obviously adapted to bring the rods, and the rods only, into definite relations to the rays of light.

While it is clearly an advantage to have stationary eyes directed towards the three planes of space, it is not so clear why the fibrils should be oriented to these planes. As chiten is said to be doubly refractive, it seemed probable that there was some relation between the presence in arthropod ocelli of chitenous polarizing lenses and parallel retinidial fibrils. But in the cases that I examined there was apparently no polarization in the principal axis of the lens, although I am not satisfied that renewed experiments may not give different results. In making the experiments I was strongly inclined to believe that in these ocelli the light was polarized in such a way that it would vibrate at right angles to the retinidial fibrils.

(5) *The Retinidial Fibrils are Arranged in accurately Graded Series according to their Length.*—The visual rods, in all the cases studied, could be resolved into a series of simple or compound wedges, hence the retinidial fibrils ought to vary in length according to their position in these wedges. The difference in length between the adjacent fibrils, although excessively small, should vary with the angle, and the number of fibrils in the series should vary with the altitude of the wedges.

PART II.

There is no reason to doubt that the structure of the visual apparatus in the higher vertebrates is essentially like that in the invertebrates, for we have succeeded in demonstrating that the retinophoræ in fishes and amphibia are twin cells like those of molluscs and arthropods (Fig. 1–[9]). We can also demonstrate that the twin cone cells of amphibia are nothing more than extreme types of the same kind of cells (Fig. 1–[10]). Furthermore, the presence of retinidial fibrils, like those of invertebrates, is clearly indicated by the well-known transverse cleavage of these rods and cones, but the fibrils themselves are probably too minute and too numerous to be clearly seen under any conditions we are as yet able to command. They are presumably arranged in distinct layers, alternating with the clear matrix of the rods and cones. Without further discussion of this point here, let us assume that the retinophoræ of verte-

FIG. 5. — Diagram to show the arrangement of the retinal cells in the ocelli of a spider, Lycosa The retinas, as seen from above, are shown on the left, and the position of the corresponding retinal cells, on a larger scale, on the right

brates are like those of invertebrates, and that the retinal cones in man have a structure something like that shown in the accompanying diagrams (Fig. 9). In Fig. 9, a cone is seen in longitudinal section with the radiating fibrils on the right of the axial fibre; on the left are projected three color curves with maxima nearly opposite *R*, *Gr*, and *V*.

Let us assume that the longest visible ether waves produce the greatest stimulation when vibrating at right angles to the longest retinidial fibrils, and the shortest visible waves produce the greatest stimulation when vibrating at right angles to the shortest fibrils. All the fibrils should be stimulated to some extent by all visible ether waves, and there should be a gradual diminution from the maximum to the minimum stimulation of any fibril according as it becomes either too short or too long to give the maximum response to an ether wave of a certain length; or provided the fibril has the optimum length, according as it diverges from a position at right angles to the plane of vibration and to the line of propagation of the wave, toward one parallel with the plane of vibration and at right angles to the line of propagation. Now let us see what will happen if we use the simplest possible stimulant, namely, a ray of light consisting of one wave length only and vibrating in one plane, that is, a polarized ray of monochromatic light. Then let us imagine, merely for economy of words, that the fibrils most stimulated by certain ether waves become luminous with the corresponding colors. Then (1) if a ray of polarized red light passes lengthwise of the cone, it should stimulate most the longest fibrils and those most nearly at right angles to its plane of vibration and to the long axis of the cone. This should produce a band of red fibrils, brightest opposite *R*, as indicated by the thickness of the lines, and fading out above and below that level, where the fibrils become either too short or too long to make the maximum response. In a cross-section of the cone opposite *R* (Fig. 9, *B*), the fibrils at right angles to the plane of vibration, say at *a*, *b*, should be the brightest, fading out on either side towards the fibrils at *c*, *d*, which, being parallel with the plane of vibration, should be stimulated but very little, if at all.

(2) If the ray were unpolarized, there would be the same maximum stimulation at R as before, with a diminution of the stimulation on either side, above and below, but all the fibrils in the same transverse plane would be stimulated alike, because all the fibrils would be at right angles to at least one plane of vibration. We may, therefore, represent graphically the effects produced by a ray of polarized or unpolarized red light by the

Fig. 6. — Vertical section of ocellus II of *Lycosa*. The section is cut at right angles to the rows of rods seen in Fig. 5.

curve r (Fig. 9, A). It should attain its maximum height a little way from the base of the cone and gradually fall to zero towards the apex, where the fibrils are too short to be affected by long ether waves. The curve will fall away more rapidly at the base of the cone because the long fibrils are supposed to terminate abruptly there.

(3) Similar results should be produced opposite V on stimulation with violet light, and of course similar results would again be produced at any intermediate point between R and V by using monochromatic light of a corresponding intermediate wave length. The stimulation curve for violet light would have

its maximum at V and would gradually fall away towards the base to zero. In the opposite direction the curve will be sharper, because the short fibrils terminate abruptly at the truncated apex of the cone. The curve for yellow-green light, on the other hand, with its apex opposite Gr, will be symmetrical because there is an equally long series of fibrils on either side of the maximum, which can respond to some extent to green light; those on one side being too short, and those on the other too long.

(4) If a beam of polarized white light be passed through the cone, the stimulated fibrils would, if luminous, appear as two opposite spectra, wedge-shaped in cross-section, extending the whole length of the cone. All the fibrils in any one transverse plane should have the same color, but the intensity of the color should gradually diminish in those fibrils that become more and more nearly parallel with the plane of vibration. The fibrils at successive levels in the cones would of course be of different colors, and these colors would be arranged lengthwise of the

FIG. 7. — Section nearly parallel with the surface of the retina of ocellus II of Lycosa.

cones in the same order as those in the spectrum. The gradation of colors in such a spectrum would be more or less abrupt, according to the angle of the cone and its altitude; that is, it

would be determined by the number of fibrils in the lineal series and upon the difference in length between adjacent fibrils. The precise colors exhibited at any part of the cone would

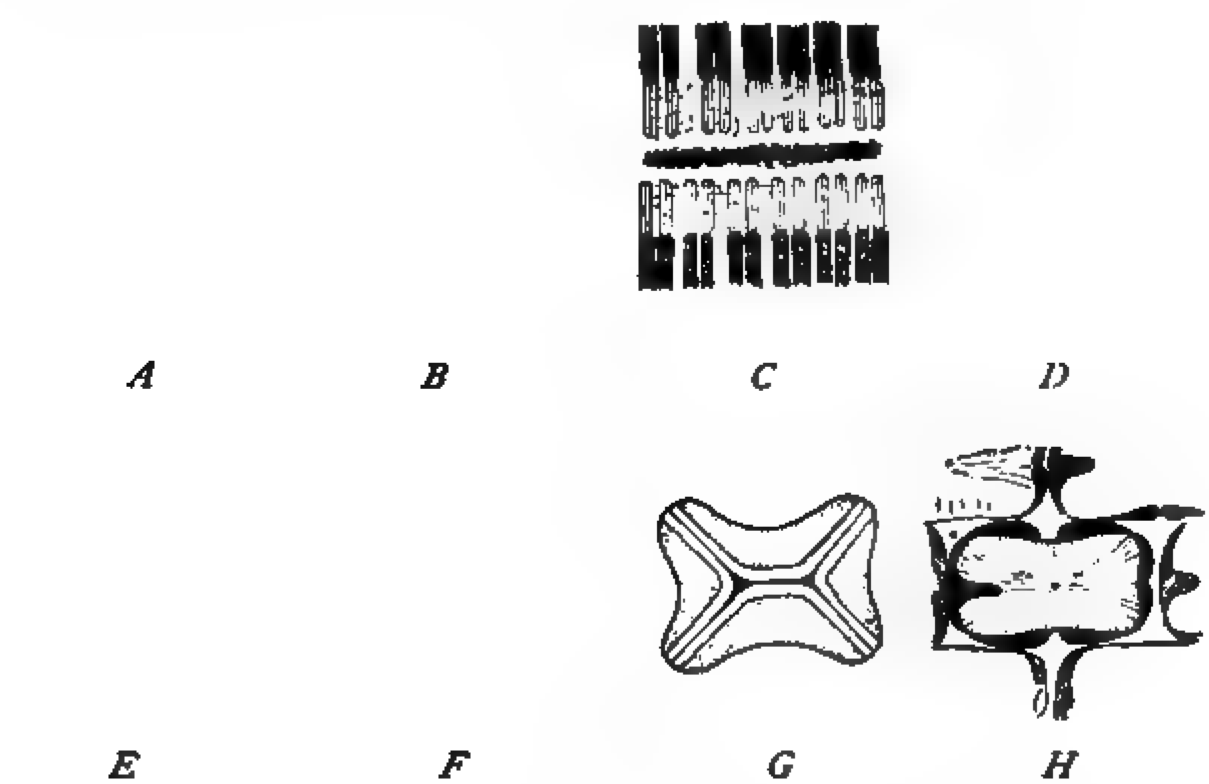

FIG. 8.—Sections through the rods of various invertebrates. *A*, Pecten; *B* and *C*, Acilius; *D*, Lycosa; *E*, Tabanus; *F*, Bdellostoma; *G*, Dytiscus; *H*, Penæus.

depend on the length of the fibrils at that point, while the range of colors exhibited would depend on the difference in length between the longest and the shortest fibrils. But the fibrils at different levels would not be equally luminous; first, since the physical and chemical properties of protoplasm must set a limit to the length of ether waves to which such fibrils can respond, it is probable that the fibres of medium length would respond better to their appropriate stimuli than the extremely long or short ones. And again, as already pointed out, since the series of fibrils terminate abruptly at the base and at the apex of the cones, unsymmetrical luminosity curves for the red and violet light should be produced with maxima, respectively, at *R* and *V*, while the luminosity curve of the intermediate yellow-green fibrils should be symmetrical. But since there is a double summation of stimulation in the middle region of the cones, — due to the partial stimulation of the fibrils that are shorter and those that are longer than the mean, — the

medium length fibrils should appear more luminous than those on either side of them. For this reason the middle part of the spectrum appears the most luminous, shading off on either side towards the absolute blackness of the ultra-red and ultra-violet.

(5) If we passed through the cone a ray of unpolarized white light, it should appear brighter than a polarized one, because it would stimulate all the fibrils in the same transverse plane. But in other respects the fibrils at different levels would present the same color effects as with polarized light.

(6) The sensation of whiteness is apparently the result of stimulating all the fibrils in one or more sectors of the cone to a nearly equal degree. Obviously, this may be done by passing through the cone all wave lengths from red to violet, or by selecting any two or more wave lengths at such a distance apart in the spectrum that through summation effects all the fibrils will be stimulated to a nearly equal degree. But if, for example, red and green light is selected, the place of maximum stimulation, owing to the summation of the two effects, will be at a point midway between the red and green fibrils, that is, at the level of the yellow fibres; hence the sensation of yellow will predominate, but it will be less saturated than the pure spectral yellow.

(7) The colors visible to a given animal should depend primarily on the various diameters of the visual elements, and the range of colors visible should depend on the difference between the maximum and minimum diameters. Hence any variation in the form or dimensions of the visual elements should be accompanied by corresponding variations in color vision. For example, increasing the length of the cones should increase the total number of fibrils of all lengths in them, and hence should be accompanied by increased powers of discrimination in all parts of the visible spectrum. We may therefore attribute the increased sensitiveness of the retina at the fovea to the greater length of the cones there, for each cone is thus provided with a greater number of fibrils to respond to any wave length within the range of vision.

Again, increasing the diameter of the base of the cones

should be accompanied by an increased range of vision at the red end of the spectrum. If the base of the cone were absent, red blindness should follow; but if the base of the cone should become cylindrical, with a diameter approaching that at *V* or *G*, then red blindness would follow, but accompanied by increased sensitiveness to the various shades of yellowish-green, because shortening the red fibrils would add so many more to the yellowish-green set.

We may also account for the gradual diminution in sensitiveness to red light toward the periphery of the retina by the fact that the cones, the bases of which alone contain the long red fibrils, diminish in number in that direction. On the other hand, on the outermost margin of

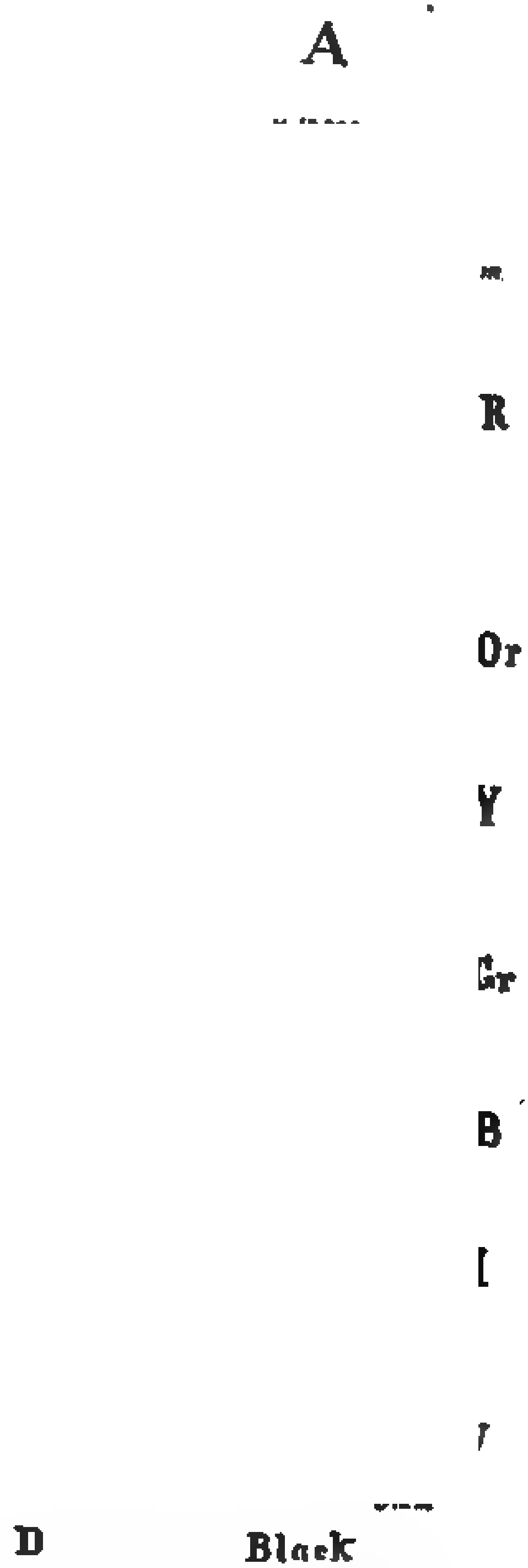

FIG. 9. — Diagram to illustrate the supposed fibrillar structure of the human cones and the way in which various light waves affect the fibrils.

the retina, all sense of color is lost and the sensation of black

and white alone remains. But this is not surprising, because towards the periphery the cones gradually disappear and the rods become the predominant elements; but since they are cylindrical bodies of uniform diameter, they must contain fibrils of one length only, — somewhat shorter than the longest cone fibrils, — consequently they cannot give rise to varied color sensations. Moreover, the periphery of the retina, judging from the manner in which the periphery grows in the invertebrates, is the youngest and least differentiated part, consequently we should not expect to find fibrils in that region which had attained just the length, position, and connections necessary in color vision.

These examples, I believe, are sufficient to show that it is a comparatively simple matter to account, from our point of view, for the more characteristic phenomena of color blindness.

(8) *The Development of Color Vision* may be explained in a similar manner. If color vision depends on the nice gradations in length or position or connection of these retinidial fibrils, the absence of these conditions should produce color blindness, but not necessarily inability to distinguish differences of light and shade. Many eyeless invertebrates react to very delicate gradations of light intensity, probably by means of the irregular networks of nerve fibrils between the epithelial cells of the naked skin. As these fibrils become phylogenetically more regularly arranged within the specialized sensory cells which serve to support them, the power to discriminate different colors should become more and more highly developed. But these conditions do not call for any particular sequence in the evolution of color sensations, for there is no reason to suppose that one set of fibrils of a given length and position would appear before another, except perhaps that a set of medium length would probably appear before the extremely short or extremely long ones, hence the sensation of yellowish-green should be the first one to emerge from that of whiteness, and subsequently it should be the most dominant and acute color sensation.

But if our views are correct, the only way in which the evolution of color vision can be worked out is by extensive

measurements, much more accurate and detailed than any heretofore made, of the visual elements in all classes of animals (also in different parts of the human retina), accompanied by an experimental study of their reactions toward different colors.

(9) *Length of the Retinidial Fibrils.* — The variation in length of organic fibrils capable of responding to ether waves is rather narrow, since there is but slight variation throughout the animal kingdom in the radius of visual rods. The length of the cross retinidial fibrils, using the radius of the rods as a guide, appears to vary roughly from less than 1 to about 4μ in length (Bdellostoma). The length of the rods may vary considerably more than this, but, as already stated, this may be taken to indicate the varying number of superimposed fibrils they contain.

The length of the retinidial fibrils in any individual must be determined primarily by the physical and chemical properties of the available protoplasm without reference to any possible advantage to be derived from a response to ether waves of a particular length. For surely there is no obvious reason why animals should not utilize for visual purposes ether waves several octaves higher or lower than they do now, if only the necessary end apparatus could be produced. But since the form of the vertebral column, or of a mountain range, is the resultant of its own composition and of the forces acting on it, and since the forms actually produced are the only ones possible under those conditions, so the form and position of the retinidial fibrils must be fixed by the inherent properties of the fibrils themselves, modified by the ether waves acting on them. We may infer, therefore, that, on the whole, animals respond to all those ether waves which are capable of modeling their available protoplasm into resonant parts.

It might be fairly demanded that since the extreme red waves visible to us are about twice as long as the extreme violet ones, the longest retinidial fibrils should be approximately twice as long as the shortest fibrils. But, judging from the very unsatisfactory data at hand, they appear to be about four times as long. For example, the longest retinidial fibrils, situated at the base of the human cones, should be about .0025 mm.

long, or about three times as long as the dark red waves. The fibrils at the apex of the cones are about one-quarter as long, or .0006 mm., or about one and one-half times longer than the violet waves. These figures, of course, are comparatively rough estimates, for exact and trustworthy measurements of fresh cones are wanting ; but they will serve to show the relations existing between the probable length of the fibrils and the ether waves to which they respond.

Since there is only one kind of an impulse sent over nerve fibrils, the discrimination of different stimuli must be determined mainly by the points of departure and arrival of impulses, that is, by the particular order and combination of fibrils stimulated ; and this in turn is determined by the position and length of the peripheral end fibrils. Such an end apparatus as we have described as existing in the human retina is apparently adequate to receive and differentiate any conceivable combination of light waves that may fall within the area of one or more cones. But in order to utilize the full capacity of such an end apparatus, each and every receiving fibril should be connected by a separate wire with the central station in the optic ganglion (or *tectum opticum* of the mid-brain in lower vertebrates or *corpora quadrigemmina* of higher vertebrates), and that in turn should be united in a similar manner with the cerebral hemispheres. But the well-known limitations of the human visual apparatus clearly demonstrate that its connections cannot be as complete as this.

The same conclusions may also be drawn from the known structure of. the retina itself. For while there are supposed to be about three and a half millions of cones and about one hundred and thirty million rods in the retina, there are only about half a million fibres in the optic nerve. Now, as every one knows, the fibres of the rod and cone cells extend only to the inner molecular layer, where they end freely in terminal brushes (Fig. 10) ; there the nervous impulses transmitted by these cells are probably picked up by a second set, which in turn end at the outer molecular layer ; and here the impulses are apparently again transferred to a third set, which send their fibres along the optic nerve to the optic centres. There are

thus three principal sets of elements, an outer, middle, and inner, through which the nervous impulses must pass before reaching the optic ganglion. The number of elements in each set, as is obvious from even a superficial examination of the retina, decreases rapidly from the outer set towards the inner, while the territory covered by their terminal brushes increases from within outwards. In other words, one element in the

FIG. 10. — Diagram to illustrate a possible mode of convergence of retinal impulses in the human retina.

middle set appears to receive impulses from many rod and cone cells, and one element in the outer set receives impulses from many elements of the middle set. There are, therefore, no indications whatever that every wave length producing the sensation of a distinct color is provided with a private wire for its sole use. On the contrary, the diminution in the number of retinal cells in each layer, and the increasing territory covered by their root-like processes as we pass from the outer surface of the retina inward, indicate very clearly that the so-called ganglionic layers do not serve to still further

complicate the processes going on within the retina, but rather to simplify them, in that they make it possible for the fibrils of the same length in many adjacent rods or cones to deliver their impulses into gradually converging channels.

Many questions arise in this connection that it is as yet hardly profitable to discuss, as, for example: How large an area of rods and cones is tributary to a single optic nerve fibre? Are these areas distinct or do they overlap each other? And, further, to what extent is there a qualitative analysis of impulses previous to convergence; that is, are all the sensations initiated in the long red fibrils of, say, three hundred cones transmitted by a single axis cylinder of the optic nerve, and if something of this kind takes place, is it true only for the red, green, and blue sensations or for ten, or twenty, or more different sensations? But whatever the answer to these questions may be, that there must be, on any theory, some kind of convergence of impulses from the rods and cones towards the optic nerve, is decisively demonstrated by the numerical relations between the rods and cones in the ganglionic cells and the fibres of the optic nerve.

Certain facts appear to indicate that there is a qualitative as well as a quantitative convergence. It is well known, for example, that the stimulation of an area as small as the base of a single cone may produce the sensation of light, but that a considerably larger area must be stimulated before the sensation of any distinct color is produced. This fact is apparently correlated with the distribution of the large ganglion cells of the inner layer, because these cells are more numerous around the fovea than on the periphery of the retina, indicating that there should be less convergence of impulses there than at the outer margin, where one ganglion cell of the inner layer must collect the impulses from a very large number of rods and cones. This appears to be the case, for we can distinguish the colors of small objects better with the centre of the retina than with the periphery; or, rather, small objects which barely produce the sensation of a distinct color when seen with the centre of the retina must be considerably increased in size in order to produce this effect when seen with the periphery.

But what is the disposition of the impulses after leaving the retina? They, of course, follow the optic nerve fibres to the optic ganglion and pass from there to the cerebral hemispheres. But why should we have these two internal centres? The conditions in Acilius furnish a partial answer, I believe, to the question. In the larvæ of this insect there are six pairs of ocelli, and each ocellus happens to have a characteristic size, shape, and arrangement of retinal cells. The nerves to the ocelli unite to form a common nerve, which near the optic ganglion again separates into six nerves, each one ending in a distinct mass of fibrillated substance. These masses of "*Punct-Substanz*" present such a striking resemblance in relative position, size, form, and structural details to the corresponding retinas that there cannot be the slightest doubt as to which ocellus each medullary core belongs. It is not claimed that there is absolute agreement between the retina and its mass of *Punct-Substanz*, but the resemblance goes so far that the singular appendage to retina I, the median furrows in retinas I to V, and the absence of this furrow in the circular retina of ocellus VI, together with the presence of a peculiar patch of inverted cells, are all represented in the corresponding part of the optic ganglion by some change in the number or arrangement of the fibrils. This is a fact of fundamental importance, and while it has been observed only in this instance where the conditions are especially favorable, the principle probably holds good for other animals as well. This similarity between the inner and outer extremities of the visual apparatus indicates that the *Punct-Substanz* of the optic ganglia consists of a series of fibrils which in their numbers and general arrangement agree with the retinidial fibrils to which they are united; and it also indicates that a series of changes initiated by light in the retina are re-presented in the optic ganglion by another sequence of changes having time and spacial relations similar to those in the retina. The whole apparatus is comparable with a telephone, or with a Marconi transmitter and receiver. As the structure of such end organs must be to a certain extent created by the ether waves that rouse them to activity, so the structure and adjustments in the optic ganglion

must be determined in part by the impulses they receive from the retina, just as certain joints, for example, have been produced by repeated stresses and movements of a particular kind. But when such joints are once established, they permit only those kinds of movements that were most instrumental in producing them, whatever may be the nature of the stimulus that initiates these movements. It is, therefore, probable, when certain adjustments have once been established in the optic ganglion through repeated retinal stimulation, that any stimulation of such a collection of fibrils might call forth the particular series of activities necessitated by such an adjustment, whether the initiatory impulse comes from within or from without. In other words, the existence of a second visual centre, or optic ganglion, having a structure similar to that of the retina, may be considered as essential in establishing for past experiences latent records, which can be brought again into activity through other stimuli than those that originally produced them. We are thus provided with a physical basis for the explanation of hallucinations and for certain phenomena of visual memory.

It is clear from known anatomical relations that the visual impulses do not cease at the optic ganglion, but are transmitted to other centres in the cerebral hemispheres, provided such hemispheres are present. While there is no animal in which the optic ganglion is not united with the anterior part of the brain, it is apparently only in the higher arthropods and in the vertebrates that it is united with a definite part of the cerebral lobes. In Limulus and scorpions, where I have made a special study of these conditions, the cerebral visual centres do not resemble in any way the optic ganglia or the retina, but their whole appearance indicates that they consist of masses of cells and fibres that serve to bring the nervous impulses received from the eyes and optic ganglia into relation with various parts of the body.

We are thus led to conclude from a comparison of widely different types of animals that the visual apparatus consists of three principal parts, which phylogenetically are developed in the order named, *viz.:* the *retina*, or receiving centre; the optic ganglion, or recording centre; and the cerebral portion, or the

coördinating and distributing centre. The structural unit of this apparatus appears to be a fibril, many hundreds of which may be present in each rod or ganglion cell. As the retinidial fibrils appear to form loops in the cones by uniting axial and external fibrils, and their central extremities terminate freely, it is possible that the retinal fibrils form elongated ∩-shaped loops, which might be compared to excessively small Hertz's resonators, the spaces between the ends of the fibrils representing the spark gaps. But whatever comparison may be made between these fibrils and any electrical device, it is not to be assumed that they actually vibrate, like tense strings, in harmony with ether waves. But while they presumably act mainly as conductors and resonators, that fact would not exclude their undergoing metabolic changes, resulting in central or peripheral fatigue or temporary exhaustion.

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SOME UNIQUE EXAMPLES OF DISPERSION OF SEEDS AND FRUITS.[1]

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In the driftwood stranded here and there along streams may often be found dry, three-celled fruits of the bladdernut an inch and a half in diameter, brown and light, tough and water-tight. The seeds are very hard and smooth, enabling them, if kept in the water, to remain uninjured for a long time. But the ability to float on the water is not its only means of dispersion. Many of the dry pods hang on until winter, rattling in the wind. On falling, a portion remain near the parent bush and are liable to be carried away the next time the creek overflows its banks; others are moved by the wind, and perhaps again by the water, and still others may be drifted for long distances, even on an up grade, if there chances to be snow on the ground.

Here, among the rubbish in spring, are some shriveled wild grapes, which missed a golden opportunity of being eaten by certain birds which could not digest their bony seeds; but they have in reserve another mode of transportation, not by wing of bird, but by floating on water. Clean grape seeds will sink at once, but when covered by the dry skin and pulp they float. In a similar manner the dry seeds of several dogwoods are often eaten by birds for the pulps, but if not eaten they behave after the manner of grapes with dry, wrinkled skins.

Narrow-leaved dock is a prominent weed, and is especially at home along ditches and river bottoms. On the back of each dry persistent sepal is an ovoid, pithy or spongy tubercle, all of which are not exactly life-preservers, but they are the next thing to it. The naked achene sinks at once when free from everything else, but when encased in its dry calyx it floats on the water.

[1] Read before Section G, American Association for the Advancement of Science, Boston Meeting, August, 1898.

In wet places sedges abound. Those of the genus Carex have each fruit enclosed by a sack (perigynium). In most sedges growing in wet land the sack is considerably larger than the enclosed achene and serves to float the denser portion. Without the perigynium the ripened achene sinks at once.

Some of the lowland sedges, like *Carex stipata* and *C. sterile*, have a perigynium only slightly inflated, but to buoy up the achene well there are small masses of corky substance inside.

Species of Carex which grow on dry land, like *C. pennsylvanica* and the rest of the tribe, have the sack fitting closely instead of inflated, and the whole mass sinks readily in the water.

In the drifted material under consideration are achenes of arrowhead, Sagittaria. They are flattened, and on one edge or both, and at the apex is a spongy ridge that serves the purpose of a raft to float the small seed within, which would sink readily if separated from the light substance that grew on its sides. In this connection may be studied achenes of Alisma, bur reed, cat-tail flag, arrow grass, burgrass, numerous potamogetons, several buttercups, the hop, nettles, false nettle, cinquefoil, avens, and others.

There grows along streams a common grass known as *Elymus virginicus*. A pair of corky, empty glumes adhere to one or more of the mature florets between them and serve as boats to carry the ripened grain to a new spot.

The compressed grain of rice-cut grass (*Homalocenchrus oryzoides*) is enclosed by a pair of glumes, and they float well on the water, but if the glumes are removed the grain drops to the bottom immediately.

Noticeable among seeds in the floodwood are some of the milkweeds, which every one would say at a glance were especially fitted for sailing through the air, aided by numerous long, silky hairs. These hairs are no hindrance to moving by water. The flat seed has a hem-like margin, which must aid the wind in blowing it about, but this margin is thickened somewhat by a spongy material. With the margin attached, it floats; without it, the seed sinks in fresh water.

The bulblets of wild garlic are numerous on the river flats, and they float readily whether dry or growing.

The Kentucky coffee-bean tree is not abundant in southern Michigan, but is oftener found along streams than elsewhere. The large pulpy pods may have induced buffalo, elk, or mastodon or other animals to eat, and thus distribute the very hard seeds, but in these times the pods usually remain on the tree till well dried, even till late in winter. When they dry they will float, carrying the seeds with them, but the seeds by themselves sink at once.

In winter we often see dead tops of lamb's-quarter and the smooth and the prickly pigweeds still standing where they grew in the summer. These are favorite feeding grounds for several kinds of small birds, especially when snow covers the ground, and at such times some of the achenes enclosed in the thin, dry calyx drop to the snow and are scattered by the wind. Birds carry away some of them, the wind blows some over the snow, and still others float on the water, buoyed by the persistent calyx. Without the calyx the achene sinks to the bottom of pond or stream.

The common locust tree blossoms, and large numbers of thin, flat pods are produced; but even when the seeds are ripe, the pods remain of a dull color. The pods of the locust wait and wait, holding fast for a long time, but nothing comes to eat them. They become dry and slowly split apart, each half of the pod usually carrying every alternate seed. Some of the pods with the seeds are torn off by the wind, and fall to the ground sooner or later, depending on the force of the wind. Each half pod as it comes off is slightly bent and twisted, and these are want advertisements given to the wind: "Here I am, thin, dry, light and elastic, twisted and bent already; give me a lift to bear these precious seeds up the hill into the valley or over the plain."

And the wind is sure to come along, a slight breeze to-day tossing the half pod a few feet, leaving it perhaps to be again and again moved further forward. I have seen them transported by this means to the distance of more than sixty yards. But many of the pods stick to the limbs till winter comes. A

breeze tears off a few pods, and they fall on the snow, which has filled up all the crevices in the grass and between the dead leaves and rubbish. Each half pod freighted with seed is admirably constructed, like an ice boat, with sail always to the breeze. In this way there is often nothing to hinder some of the seeds from going a mile or two in a few minutes, now and then striking some object which jars off a seed or two. The seeds are very hard, and no doubt purposely so, that they may be seldom eaten by insects or birds; but once in moist soil, the covering slowly swells and decays, allowing the young plant to escape. Thus the locust seeds are provided with neither legs, wings, fins, nor do they advertise by brilliant hue and sweet pulp, but they travel in a way of their own, and literally on the wings of the wind.

On lowlands, more or less abundant throughout the Northern Temperate Zone, is found the great willow-herb, *Epilobium angustifolium*. When ripe the slender pod slowly recurves from the top into four pieces and exposes the very small seeds, each having at one end a tuft of fine, white, silky hairs nearly half an inch long. Almost every one would think the seeds grew in this manner to be scattered by the wind, and no doubt this is correct. I call your attention to the plant for the purpose of showing that the tips of the hairs stick slightly to grooves inside of the recurved valves, some hairs to one valve, and often others to the adjacent valve, thus spreading them apart with the seed suspended between. Four rows of the seeds are thus held out at one time. Not over half to a tenth part of the seeds are well developed, yet the silky hairs are present and float away in clusters, helping to buoy those that are heavy. This is a capital device, and when dry and unfurled, it silently indicates to the slightest breath of air that the seeds are ready for a flight, and it does not take much to carry them a long distance.

Do you know why so many kinds of plants produce very small and light seeds? Would it not be better if they produced fewer and larger seeds which would be stronger and better able to grow under adverse conditions? But many small seeds cost the plant no more effort than a small number of large ones.

The lighter and smaller the seeds, and the more there are of them, the better their chances for distribution, especially for long distances. The minute size of spores of most of the fungi are given as a reason why so many of them are so widely distributed. Why is a boy or man of light weight secured to ride the horse on the race track? That the animal may have less weight to carry, and thereby use his surplus strength in making better time. The less weight the parachute of the seed of the willow-herb has to carry, the greater the chances for success in making a long journey. Of the willow-herb, it takes one hundred seeds to weigh a milligram, including the hairs attached to them, and it would take thirty thousand to weigh as much as an ordinary white bean.

Ripened pods of *Lilium superbum* usually stand straight up on a stiff elastic stem; beginning at the top, each one slowly splits, and the three parts separate from each other. Why do they not burst open all of a sudden, like pea pods, and shoot the seeds all about, and have the job done with? Or why does not the pod burst open at the lower end first instead of the upper? Observe that the coverings of the cavities are lashed together loosely with a latticework. No slight breeze can dislodge the seeds, but just see how they behave in a gale! The elastic stems are swayed back and forth against each other, and some of the upper seeds are tossed out by the wind which passes through the lattice, and at such times are carried forward. The seeds at the top having escaped, the dry pods split down farther and still farther, and open still wider, till the bottom is reached. Succeeding breezes may come from different directions, and, as the seeds are not all carried away the first, or even the second time, there are some left to be scattered about.

The seeds of the lily are flat and rather light, not to be shot out like bullets, but to be carried a little way by the wind; the pods are erect and open at the top, that they need not escape when there is no wind unless some animal gives the stem a strong shake. I mention this plant on purpose to call your attention to the admirable scheme for economizing the supply of seeds. The latticework was made for a purpose, and the

gradual opening of the pods prevents the supply from all going at one time in one direction or in one day, when a better day may arrive.

We shall find nearly or all flattened seeds or fruits are one-sided, unbalanced, and more or less twisted, so in falling to the ground they whirl about and are thus kept much longer in the air than they would be if shaped more like a winged arrow. Even the wings on the fruit of some of the ashes are twisted, though many of them are flat.

There are a number of rather weedy-looking herbs, common to woods or lowland, known as avens (Geum). They are closely allied to cinquefoil, and all belong to the rose family. The slender styles above the seed-like ovaries of some species of avens are described not as jointed, but straight and feathery, well adapted, as we might suppose, to be scattered by the wind, while others are spoken of as having, when young, styles jointed and bent near the middle. In maturing, the lower part of the style becomes much longer and stouter. When a whole head of pistils has drawn all the nourishment possible, and all that is needed from the mother plant, the upper part of each style drops off, leaving a sharp, stiff hook at the end. At that time each pistil loosens from the head and can be easily removed, especially if some animal touches the hooks. To help in holding fast, there are a number of slender hairs farther down the style which are liable to become more or less entangled in hairs, fur, wool, or feathers. Even in the small number of plants here noticed, we have seen that scarcely any two of them agree in the details of their devices for securing transportation of seeds. I know of nothing like the Geum we are now considering. When young and green, the tip of each hook is securely protected by a knob or bunch with a little arm extending above, which effectually prevents the hook from catching on to anything, but when the fruit is ripe, the projecting knob with its little attachment disappears.

Nycandra physaloides, or Apple of Peru, a coarse annual sometimes cultivated, is spoken of by Gray as bearing dry berries. Each suspended berry is covered by a five-parted inflated calyx. The edges of the sepals come together and

project outward, making a secure covering for the fruit. In time the berry and the papery calyx ripen, and the pedicel becomes stiff and elastic. In five places close up under the calyx the "skin" of the fruit splits open and rolls slowly back, exposing seeds. The dry dehiscent pods of most kinds of plants become wet, close up more or less, and suspend the scattering of seeds in time of a shower. Not so with Nycandra, for each berry is kept dry by an umbrella, cap, or shed, which nature has deftly built. The numerous persistent, inflated calyxes expose much surface to the wind, even after the leaves have left the dry plant. The dead plant is rattled about by every breeze, scattering seeds freely. While these are dropping, the five scrolls on the surface continue to open further and further, permitting more seeds to fall.

Some friends of mine collected a quantity of hazel nuts and placed them near the house, while yet the green husks enclosed the nuts. At once they were discovered by a blue jay, which picked out a nut at a time, flew away, held the nut between its toes, cracked it from the apex, and ate the contents. In this operation a number of nuts slipped away and were lost. Half a dozen or more grew, and to-day a new patch of hazel bushes is growing in the yard.

The unicorn plant (*Martynia proboscidea*) is a coarse diffuse herb found growing from southern Indiana to Iowa and northern Mexico. The ripened fruit is oblong, about three inches long and an inch in diameter, with a beak at the base, and two long, slender, spreading and incurved points at the apex. On the side of the fruit next to the long curved beaks is a crest, consisting of stiff pieces a fourth of an inch long. The whole is tough, hard, and elastic. The three beaks curve toward each other, roughly outlining two-thirds of a circle with a diameter of five inches. It is a queer-looking thing, difficult to describe. A peck of them placed in a basket hold together well, having developed the propensity "to catch on" to a remarkable degree. The three beaks curving toward each other, with the crest inside the ring, adapt it admirably to become attached to the feet of cattle, sheep, horses, and the buffalo, which once roamed over this region in great abundance.

Since reading the above concerning Martynia, J. B. S. Norton, of the Botanical Garden, St. Louis, informed me that he had often seen the points hanging on the feet of cattle or horses on the prairies of Kansas, where the plant in many places has become a bad weed. In some instances several points were seen attached to one foot.

MICHIGAN AGRICULTURAL COLLEGE.

THE ADVANCE OF BIOLOGY IN 1896.

C. B. DAVENPORT.

THE appearance of the second volume of *L'Année Biologique*,[1] with its valuable summaries of progress in general biology, gives the opportunity for a second summary of progress like that published in the *Naturalist* last year.

Cytology. — Five good text-books on this subject appeared during the year by Wilson, by Henneguy, by Fol, by Delage and Hérouard, and by Zimmermann. The idea of a diversity in protoplasmic structure, sometimes fibrillar, sometimes reticulated, sometimes vacuolated, grew, especially among those who at first opposed Bütschli's foam theory of protoplasmic structure. Nadson's discovery of nuclear matter in Cyanophyces was confirmed, with modifications, by Bütschli, who also finds it in bacteria. The chemical constitution of the nucleus received a little attention. Korschelt classified the chromatin as either basichromatin, occurring in one or more large masses, or as oxychromatin, occurring as fine granules. The known distribution of the centrosome was enlarged, its occurrence being recorded for several Protozoa, diatoms, and the ganglionic cells of vertebrates and an invertebrate (Lewis). On the other hand, Strasburger's pupils did not find it in tissue cells of phenogams. The occurrence of a centrosome in ganglionic cells, which are believed not to divide, spoke for its being a permanent cell-organ. The true relation of centrosome to attraction sphere remained to be elucidated.

Cell-division was further analyzed. The universal presence in the spindle of fibres running from one pole to the other became more generally admitted. The discussion over the origin of the spindle continued, great deviations from the type described for the salamander epithelium were made known, and the nuclear origin of the spindle was maintained for both plants and animals. Attention was especially directed, by Erlanger and

[1] *L'Année Biologique.* Edited by Yves Delage. Vol. ii, 1896. Paris, Schleicher Frères, 1898. 8vo., 35 + 808 pp.

Henneguy, towards the accessory cell bodies ("Nebenkerne"), of which several kinds, differing in origin, were distinguished. The idea that amitosis in a cell sounds its death knell was opposed by strong cases.

Experiments to control cell-division were multiplied. The well-known hastening of cell-division by heat was observed again. Induced electric currents provoked direct division in salamander epithelium, and determined that thè dividing plane should be transverse to the current (Galeotti). Norman confirmed Loeb's assertion, that in dense solutions cytoplasmic cleavage might be inhibited without interfering with nuclear division. Boveri showed that in a cleavage sphere containing archoplasm, but no chromatin, division of the archoplasm might continue in the absence of chromatin. The independence of nucleus and cytoplasm grew more evident.

The Sexual Products and Fecundation.—Chromatin reduction was observed in Heliozoa (Schaudinn) and Coccidiidæ (Labbé)—thus among the simplest organisms. The history of the origin of the sex-cells and their periods of multiplication and of rest were traced by Eigenmann in a viviparous fish. The question of the locus of the centrosome in the spermatozoon was undergoing debate. As for *fecundation*, the belief that the archoplasm of the female plays no part in egg-cleavage was unanimously confirmed by the several workers upon this subject.

Parthenogenesis. — The observation of last year on the absence of true parthenogenesis in the unfertilized eggs of the higher vertebrates was confirmed. Parthenogenesis in the lower algæ was induced artificially. It was stated (Zur Strassen) that two eggs of Ascaris may fuse, giving rise to a zygote capable of developing into a giant embryo.

Asexual Reproduction. — New cases of reproduction by autotomy were described for a holothurian and a nemertean. Attention was again called (by Seeliger) to the non-parallelism between budding and egg-ontogeny, and Ritter insisted on the origin of buds in Tunicates from embryonic tissue.

Ontogenesis. — The truth that in development preformation and epigenesis are blended, which was dawning in 1895, became still clearer as a result of the work of 1896. Especially was

this due to the results of Crampton, who showed that in the gastropod Ilyanassa, when the mesodermal pole cells are removed, no mesodermal structures are produced in the embryo. Thus there is here, at a certain late cleavage stage, a specialization of cells in the germ. The series of specialization, which finds its lower extreme in the medusa and its higher extreme in the gastropod, is, however, not shown to be one of specialization of nuclear material, but rather of cytoplasmic material only. In so far as the cytoplasm of the germ is specialized, in so far is there preformation in the germ. In so far, on the other hand, as the fate of a portion of the germ is determined by its position in the body, development is epigenetic. The variation in the degree of preformation is due to the fact that the cytoplasm of some eggs exhibits little responsiveness, that of others a great deal. New evidence for the unspecialized character of the nuclei was given by Wilson, who found that potential micromeres of Nereis, forced to become macromeres, had the fate of macromeres. Last year it was shown that one-fiftieth of an echinoid egg might develop; this year Lillie showed that one-twenty-seventh of a Stentor is capable of forming a new individual. Jennings showed that the axis of the spindle in a developing rotifer egg is not always placed in the greatest extent of the cytoplasm (Hertwig's law), but occupies various positions. The spindle is sometimes stimulated by the form of the cell to lie in its long axis, at other times to lie in its short axis, and at still other times to lie obliquely. Among attempts at a mechanical explanation of ontogenesis were those of Roux, who showed that the lines of contact of oil drops resemble those of cleavage spheres. The theory of development as a response to stimuli was enriched by the experiment of Driesch, which showed that the mesenchymatous cells of echinoid gastrulas, disarranged by shaking, return to their respective places. Self-regulation was illustrated by the observations that variations in the embryo are greater than in the adult (whence they must gradually become obliterated during development), that with shortened range of contraction of a muscle its tendinous part is increased at expense of its contractile part, and that a bone called upon to carry an abnormally great weight increases in

diameter. Of these self-regulations Driesch distinguished two categories — primary, involving only normal ontogenetic processes, and secondary, involving ontogenetic processes of a new and special sort.

Teratology. — The most important work of the year in comparative teratology was that of Patten on abnormalities in the development of Limulus. In attempting to produce monstrosities by physical agents, Bataillon made the axis of the embryo frog lie perpendicular to that of the first cleavage plane (hence perpendicular to its normal position) by pressure, Rossi found that electricity has less effect the older the embryo, the fact that the different chemical solutions have specific effects on echinoid ontogeny was determined for echinoids by Herbst and for Amphibia by Gurwitsch, Samassa ascertained that pure oxygen has little effect on the development of the frog, and Féré found that the venom of the viper provokes anomalies in the development of the chick. De Vries showed that a highly nutritive culture-medium tends to accentuate the monstrous characters of individuals of a race of plants which is tending to revert to the normal type. Several unusual and well-worked-out cases of abnormalities in invertebrates were described by morphologists.

Regeneration. — While the multiplication of cases of regeneration continued as in former years, the principal lines of advance in 1896 were first in the clearer recognition of the fact that in regeneration an organ often arises from dissimilar germ-layers and develops in a different manner than it does in egg development ; and, secondly, that regeneration is often accompanied by heteromorphosis. In the first category we have Wolff's case of regeneration of the lens from the mesoderm of the iris of Amphibia, this year abundantly confirmed. According to both Michel and Hepke, the ectoderm of the earthworm gives rise to all the regenerating tissues. In the second category of cases we place the observations that regenerating eyes of shrimps may produce antenniform organs, that the regenerating antennæ of the lobster have a spiral form, that planarians, whose margins have been incised, may form multiple heads, and that the regenerated tails of lizards are of simpler organization

than the normal ones. In the case of Crustacea the normal form of the organ may reappear after several molts (Przibram). A very extended study on regenerations in earthworms was made by Heschler.

Grafting. — This year afforded the marvelously successful results of Joest in grafting earthworms, not only one part of the worm being united to another part, but one individual to another.

Sex and Secondary Sexual Characters. — New experiments on sex control confirmed, on the whole, the idea that femaleness results from rich nutrition. Marchal showed that neuter wasps, when through the death or sterility of the queen there are no young in the nests, feed on the larval food and become fertile females.

Polymorphism, Metamorphosis, and Alternation of Generations. —Some advance was made this year in answering the question, Is polymorphism blastogenic or somatogenic? What rôle do the intrinsic conditions of the individual play, and what environment? No doubt there must be a substratum capable of responding in two or more ways, but which response shall be called into action, and how far it shall go, these are determined by extrinsic factors. The theory that a double habit (*e.g.*, the habit of a gall insect in stinging two kinds of trees) may lead to polymorphism was advanced by Beijerinck.

Correlation. —The most important contribution of the year was that which Pearson made to the mathematical study of the subject. Several authors contributed exact data on correlation in various species. Many special cases of correlation were described.

General Morphology and Physiology. — The discussion over the significance of the cell as a unit in the body was continued in France by Delage and Le Dantec. The idea that metameres are, phylogenetically, secondary divisions of the trunk gained ground.

One of the most important works of the year in general physiology was that of Loew, on the *Energy of Living Protoplasm*, in which the chemical explanation dominated. Progress was made towards a clearer understanding of the way in which sun-

light is transformed into the specific, assimulative energy by chlorophyll. Tschirsch showed that chlorophyll and hæmoglobin probably originate in the same fundamental substance. The question of the process of albumen formation in plants was a burning one. Internal secretions attracted ever-increasing attention. Our knowledge of the rôle and physics of osmosis in organisms and the action on organisms of light, electricity, (Loeb, Verworn), and chemical substances received important additions, as did also phygocytosis and the action of ferments.

Heredity.—The year revealed an increased tendency towards experimentation. Boveri's evidence for a hybrid without maternal characters was almost annulled by the opposing investigations of Seeliger. In the matter of inheritance of acquired characters new experiments by Charrin and Gley indicated the inheritance of immunity. Loeb, testing the hypothesis that the nervous system acts as an intermediary between soma and germ cells, finds that the amphibian larva develops normally even after the axial nervous system has been severed. Very noteworthy is the fact that Ewart repeated Lord Morton's experiment in telegony with somewhat confirmatory results.

Variation.—The quantitative study of this subject has made good progress. Pearson investigated the mathematical laws of regression, heredity, and panmixia. Ludwig, Amann, Warren, and Thompson applied the quantitative methods to the variation of various species. Agassiz and Woodworth found the variations in a medusa — Eucope — only such as are normal in other species. The great variation in embryonic as compared with adult stages was gaining more general recognition.

Origin of Species. — The principal papers of the year were speculative. Weismann added to his system the conception of a struggle in the germ plasm by which those determinants which gain a slight advantage over their fellows soon get the upper hand. The theory of mimicry was strongly attacked (*e.g.*, by Piepers, after many years of observations in the Malays). The struggle around the theories of natural selection and the utility of specific characters continued. Many cases of considerable variations due to environment, forming probable starting points of species, were described.

The Nervous System and Mental Functions. — Great activity was displayed in the study of the structure of the nerve cell, yet the significance of the chromophile substance and the fundamental substance remained in dispute, Ramon y Cajal regarding the former as a nutritive reserve. The variations of the nerve cell in different states of function and health were the subject of much attention. The results of the immense activity in the fields of sensations, instincts, and emotions cannot be summarized.

General Theories. — The most important theoretical work of the year was probably Cope's *Factors of Organic Evolution.* Important also were Weismann's *Ueber Germinal Selection* and Le Dantec's *Théorie nouvelle de la vie.*

Of the subjects considered in *L'Année Biologique* five seem developing with magnificent rapidity — cytology, experimental morphology, general physiology, variation, and the nervous system. Already there are indications of the not far distant blending of the results of the work in all of these lines of investigation.

EDITORIALS.

The New York State College of Forestry. — In April last, the Legislature of New York passed an important Act, authorizing the Trustees of Cornell University "to create and establish a department in said University, to be known as and called the New York State College of Forestry, for the purpose of education and instruction in the principles and practices of scientific forestry." Provision was also made for the establishment of a demonstration forest of not more than 30,000 acres, in the Adirondacks, which is to be known as the "College forest." Since the organization of the several agricultural experiment stations on a national basis of support, no public endowment of applied science has at all approached this of the state of New York in prospective usefulness to the public at large.

From an announcement of the new College of Forestry, recently issued, it appears that the annual consumption of wood materials in the United States is estimated at over 20,000,000,000 cubic feet, valued when shaped for use in the arts at not less than $1,000,000,000. Much of this material is doubtless capable of profitable, even though in the first instance more expensive, replacement by other material; and although many notes of warning have been sounded, and for some years a national forestry association has occupied itself with the formation of public opinion, favorable to a rational administration of our forests, it is probably true to-day that private landowners cannot view investment in forest lands, to be rationally administered, as desirable from a business point of view, partly because of the slowness with which returns are received. But in Europe the necessity of such administration of what is left of the original forests, and of the very large areas that have been planted to take the place of those denuded, has come to be generally understood. Under the management of Professor Fernow, who has been called to its head, the new College of Forestry may be expected to disseminate the best and most practical of information on all matters connected with the subject, and it is probable that long before the expiration of Cornell's thirty years' title to the "College forest," it will have served as the model for many and larger state and national forest reservations, which will be not only safely preserved but administered for the public benefit.

The Concilium Bibliographicum. — We are glad to receive, unfortunately too late for insertion in the present issue, an account of the work of the Concilium Bibliographicum, from which we learn that this enterprise is now firmly established, the Swiss Confederation, the Canton, and the town of Zurich having voted a permanent subsidy for its support.

The Concilium was founded in 1896, by Dr. Herbert Haviland Field, with the view of furnishing zoologists with a more complete bibliography than had existed heretofore. The plan is to issue a classed card catalogue of current zoological literature, taking into account not only all books and papers issued but also parts of papers when they treat of distinct subjects. This large undertaking has involved an immense amount of work for Dr. Field, as well as a very considerable expense, and he should receive the cordial support of every zoologist.

It is not expected that individuals will care to subscribe for the whole series of cards, and orders will be received for as small a part as any one may want. Every worker in zoology may profit, therefore, by Dr. Field's labor, and at the same time aid him in this most useful and unselfish enterprise.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Prehistoric Burial Places in Maine.[1] — Mr. Willoughby's paper is noteworthy for its exposition of modern methods of archæological research. At every step in the progress of the work of exploration of the three burial places described, sketches, photographs, and measurements were taken with painstaking care so that the author is enabled to present the facts clearly and concisely. His work may well serve as a model for those untrained observers who, sincerely desirous of reading these perishable records of camp site and grave, but too frequently succeed only in destroying them.

The cemeteries explored are shown to be very old; the implements[2] found in them differ somewhat from those used by the Algonquins who inhabited the region at the time of the discovery. We note that the slender spear points of slate resemble those used by the Indians of the Barren Ground of Canada at the present time for killing caribou by thrusts in the back as the animals are swimming across lakes and streams in summer.

In conclusion the author suggests that these cemeteries may have been used by the Beothuks, the last remnant of whom perished in the central part of Newfoundland during the early part of this century. The discovery of a single cemetery of this interesting people would probably solve the problem raised by Mr. Willoughby's investigations, and also determine the relationships of the Beothuks to the tribes around them. A railway has invaded the Red Indian Lake region, and it is now easily accessible; it is to be hoped that a larger series of crania may be discovered, or at least that the few skulls now known may be studied by a trained somatologist.

[1] Willoughby, Charles C. Prehistoric Burial Places in Maine, *Archæological and Ethnological Papers of the Peabody Museum*. Harvard University. Vol. i (1898), No. 6.

[2] In the quotation from Dr. Hough's valuable paper on the Fire-Making Apparatus in the U. S. National Museum the statement is made that pyrites were probably used in kindling fire at Herschel Island (and other points east). This may be regarded as a certainty, as we have collected specimens of Eskimo fire-bags containing pyrites at Herschel Island and know that it is so used.

GENERAL BIOLOGY.

Filose Activity in Metazoan Eggs. — Any new facts that throw light upon the complicated problem of the relations to one another of the cells in an organism are exceedingly welcome. We note with pleasure, therefore, an article[1] by Prof. E. A. Andrews, giving a summary of his researches upon the formation of pseudopodia-like processes in metazoan eggs, to which Mrs. Andrews first clearly called attention in 1897.[2]

The filose processes are described as extremely fine protoplasmic threads arising from the surface of blastomeres in various stages of cleavage. They traverse the blastocœl, and frequently become attached to other blastomeres or to the polar bodies, which also give rise to similar processes. The threads may branch, and the protoplasm flowing along them may collect in nodules, especially at the points of origin of the branches.

These filose phenomena were observed in living eggs of a nudibranch mollusk, *Tergipes despectus* (?); a lamellibranch, *Yoldia limatula;* a nemertean, *Cerebratulus lacteus* Verrill; an annelid, Serpula; and echinoderms.

Among the Chordata, preserved material only was available. In sections of cleavage and larval stages of the salamander *Amblystoma punctatum*, and in certain frog's eggs, undoubted protoplasmic connections between the cells were observed, but their normal filose character was not certain. Eggs of Amphioxus in four, eight, and sixteen-cell stages showed marked intercellular connections. In the illustrations these are seen to be filaments of considerable length, extending across the cleavage cavity. Figures of the filose processes found in living and in preserved echinoderm eggs are introduced for comparison, and support the view that the filaments in the egg of Amphioxus are of the same character.

If the filose phenomena are as widely distributed throughout the animal kingdom as this paper would lead one to suppose, they will become surely an important factor in future theories of ontogeny.

R. P. B.

A Plea for the Theory of Special Creation. — While the methods of evolution still furnish matter for discussion, one might suppose

[1] Andrews, E. A. Filose Activity in Metazoan Eggs, *Zoological Bulletin*, vol. ii (July, 1898), No. 1, pp. 1–13.

[2] *Journ. of Morph.*, vol. xii, No. 2.

that, for scientific people at least, the central fact of organic evolution had been established beyond question. In opposition to this view, we have a book of nearly 400 pages, by Prof. Alfred Fairhurst,[1] who has been "for many years a teacher of various branches of natural science." We doubt, however, whether his arguments will be found convincing by many who have paid very much attention to the biological sciences. The object of the book is "to promote the belief in Theism and in the existence of a spiritual nature in man which Theism alone can explain." Therefore, the author attacks evolution, not because Theism and the doctrine of evolution are necessarily antagonistic, — the author does not think that they are, — but because the belief in Theism in some people has been decreased by the propagation of the theory of evolution.

The difficulties that the author arrays against evolution are the old familiar ones: the origin of living material, the survival of primitive types, divergent evolution, absence of "missing links," the appearance of highly organized forms in early fossiliferous rocks, uselessness of nascent organs, instinct, and the like. He does not attach much weight to the evidence from homologies and vestigeal organs. For example, "they (fins) are said to be homologous to the limbs of higher vertebrates, but I regard the homology as far-fetched." Again, "embryo man with gill arches is still man, and if we can read the lesson within it, we will find that this embryo man points upward to adult man with all of his marvelous powers of mind, and not downward to something infinitely below him."

To properly answer arguments presented from the point of view of this book, one would have to preface his remarks by a treatise on elementary biology, comparative anatomy, and embryology, and introduce a chapter on the natural history of animals and plants, with remarks on fossilization. The limits of a review will hardly permit this.

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Fusion of Pupæ. — In the Woods Holl Lectures for 1896 and 1897,[2] Henry E. Crampton, Jr., gives an interesting account of his experiments upon the pupæ of Lepidoptera. By cutting away portions of two pupæ, and joining the cut surfaces, he was able in many

[1] Fairhurst, Alfred. *Organic Evolution Considered.* St. Louis, Christian Pub. Co., 1897. 8vo., 386 pp.

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R. P. B.

A Plea for the Theory of Special Creation. — While the methods of evolution still furnish matter for discussion, one might suppose

[1] Andrews, E. A. Filose Activity in Metazoan Eggs, *Zoological Bulletin*, vol. ii (July, 1898), No. 1, pp. 1–13.

[2] *Journ. of Morph.*, vol. xii, No. 2.

that, for scientific people at least, the central fact of organic evolution had been established beyond question. In opposition to this view, we have a book of nearly 400 pages, by Prof. Alfred Fairhurst,[1] who has been "for many years a teacher of various branches of natural science." We doubt, however, whether his arguments will be found convincing by many who have paid very much attention to the biological sciences. The object of the book is "to promote the belief in Theism and in the existence of a spiritual nature in man which Theism alone can explain." Therefore, the author attacks evolution, not because Theism and the doctrine of evolution are necessarily antagonistic, — the author does not think that they are, — but because the belief in Theism in some people has been decreased by the propagation of the theory of evolution.

The difficulties that the author arrays against evolution are the old familiar ones: the origin of living material, the survival of primitive types, divergent evolution, absence of "missing links," the appearance of highly organized forms in early fossiliferous rocks, uselessness of nascent organs, instinct, and the like. He does not attach much weight to the evidence from homologies and vestigeal organs. For example, "they (fins) are said to be homologous to the limbs of higher vertebrates, but I regard the homology as far-fetched." Again, "embryo man with gill arches is still man, and if we can read the lesson within it, we will find that this embryo man points upward to adult man with all of his marvelous powers of mind, and not downward to something infinitely below him."

To properly answer arguments presented from the point of view of this book, one would have to preface his remarks by a treatise on elementary biology, comparative anatomy, and embryology, and introduce a chapter on the natural history of animals and plants, with remarks on fossilization. The limits of a review will hardly permit this.

R. P. B.

Fusion of Pupæ. — In the Woods Holl Lectures for 1896 and 1897,[2] Henry E. Crampton, Jr., gives an interesting account of his experiments upon the pupæ of Lepidoptera. By cutting away portions of two pupæ, and joining the cut surfaces, he was able in many

[1] Fairhurst, Alfred. *Organic Evolution Considered.* St. Louis, Christian Pub. Co., 1897. 8vo., 386 pp.

[2] Crampton, Henry E., Jr. Coalescence Experiments upon the Lepidoptera, *Biological Lectures delivered at the Marine Biological Laboratory of Woods Holl.* Boston, Ginn & Company, 1898. pp. 219–228.

the hopes entertained, and there is every reason to expect that other bulletins now in hand will be equally useful. T.

Life Zones and Crop Zones. — Under this title Dr. C. Hart Merriam has recently published an important bulletin from the division of biological survey of the United States Department of Agriculture. The paper is accompanied by a map, in color, which shows at once the distribution of what are called the boreal, transition, upper austral, lower austral, Gulf strip of lower austral, and tropical zones, and the humid divisions of the austral zones east of the great plains. If, as the author hopes, this and similar reports tend to guide experimental agriculture into rational lines, it will be paid for in saving to the country many times over in a single year. T.

Bray's Lower Sonoran Flora. — In the *Botanical Gazette* for August, Prof. W. L. Bray publishes an important paper "on the relation of the flora of the lower Sonoran zone in North America to the flora of the arid zones of Chili and Argentine," in which are embodied the results of studies carried out at the suggestion of Professor Engler of Berlin. The general conclusion is reached that for most species the distribution and relationships in the two zones are such as can be accounted for from data that are reasonably well established, while the element which remains rests upon very much the same basis of speculation as the relation of all of the great salt desert regions of the world to each other.

East Indian Iron Woods. — *Bulletin No. 19* of the Koloniaal Museum of Haarlem, issued in July, is devoted to a consideration of the anatomical structure of the iron woods of the Indies, to which is added a list of plants from other parts of the world to which this name is applied. A set of very good cross-section plates adds to the usefulness of the article.

Botanical Notes. — The September number of the *Bulletin of the Torrey Botanical Club* contains No. 16 of Dr. Small's studies in the botany of the southeastern United States, chiefly occupied with descriptions of new species peculiar to that region; a paper by Professor Porter on the flora of the lower Susquehanna; No. 24 of the

78 pp., with 1 map. — Bulletin No. 2 (Scientific Series, No. 1). On the Instincts and Habits of the Solitary Wasps. By George W. Peckham and Elizabeth G. Peckham. iv + 245 pp., 14 pls. Madison, 1878.

enumeration of Dr. Rusby's plants collected in South America in 1885–1886; the description of a new Floridan Utricularia, by J. H. Barnhart; and a paper by Ellis and Everhart, descriptive of new species of fungi from various localities.

H. B. Small, in *The Ottawa Naturalist*, is publishing a series of popular articles on vegetation in the Bermudas.

The genus *Arenaria* is revised in a descriptive monograph in Nos. 232, 233 of the *Journal of the Linnean Society*, dated July 1, 1898, by F. N. Williams, whose critical notes on *Cerastium* are running through the current numbers of the *Journal of Botany*.

Ledum glandulosum, of the northwest coast region, is well figured in No. 1338 of the *Botanical Magazine*.

Viburnum tomentosum and its variety *plicatum* form the subject of an interesting illustrated article by A. Rehder in Möller's *Deutsche Gärtner-Zeitung* for August.

Aristolochia sipho, as grown in the botanical garden at Jena, is figured in Möller's *Deutsche Gärtner-Zeitung* of August 13.

The *Liliaceae* of the French Congo are brought together in a revision by Hua in the *Bulletin of the Société d'Histoire Naturelle d'Autun* for 1897. As might have been expected, a large part of the species are described as new.

Under the title *Studies on American Grasses*, the United States Department of Agriculture issues as *Bulletin No. 11* of its Division of Agrostology a revision of the North American species of Calamagrostis, by T. H. Kearney, and descriptions of a number of new or little-known grasses, by F. Lamson-Scribner. Seventeen plates and twelve figures in the text illustrate the papers.

The *Bulletin* of the Natural History Society of New Brunswick, No. 16, recently issued, contains a list of 245 mosses occurring in the Province.

In the July number of *Hedwigia*, Rehm publishes a fourth part of his notes on the fungi collected in Brazil by Ule, and Dietel publishes some observations on the Uredineae of Mexico.

SCIENTIFIC NEWS.

For many years Canon A. M. Norman has been a diligent student of the marine invertebrates of northern seas, and as a result has accumulated collections rich in types of his own and his collaborator's new species. These have now been purchased by the British Museum.

Prof. Michael Foster will be president of the British Association at the meeting at Dover in 1899.

Dr. W. McM. Woodworth has gone to the Samoan Islands in the interest of the Museum of Comparative Zoology.

The anthropological expedition, under charge of Prof. Alfred C. Haddon, has reached Murray Island, where a laboratory has been established in the same building which Dr. Haddon occupied during his previous visit to the island.

The United States Fish Commission has rediscovered a school of the valuable and interesting tile fish about seventy miles south of Martha's Vineyard.

Sir William Flower has resigned the directorship of the British Museum (Natural History) on the grounds of ill-health.

The British government is establishing a botanic garden and experiment station in Uganda under the direction of Mr. Alexander Whyte.

A striking commentary upon the demand for agricultural education is furnished by the enrollment last year in the State University of the agricultural state of Nebraska. Out of a total enrollment of 1915 there were 36 in the agricultural and mechanical school.

Dr. A. Möller, of Eberswald, Prussia, is engaged on a life of Fritz Müller, and desires letters, etc., which will aid in the preparation of his memoir.

John P. Marshall, professor of geology in Tufts College since its foundation (1855), has been made professor emeritus.

Mr. R. D. Lacoe, of Pittston, Pa., has added to his gifts to the National Museum the fossil insects in his collection, amounting to many thousand specimens.

At the annual meeting of the Marine Biological Laboratory at Woods Holl, August 9, the following trustees were elected to serve for four years: E. G. Conklin, Camillus G. Kidder, Maynard M. Metcalf, William Patten, D. P. Penhallow, and W. B. Scott. The other trustees hold over. The officers elected were: Henry F. Osborn, president; Charles O. Whitman, director; James I. Peck, assistant director; Hermon C. Bumpus, secretary; and D. Blakely Hoar, treasurer. It is hoped that when the books for the year are closed there will be no deficit.

Mrs. Emmons Blaine has given $250,000 to Chicago University for the establishment of a College for Teachers.

The Hayden geological medal of the Academy of Natural Sciences of Philadelphia was awarded for the year 1898 to Dr. Otto Martin Thorell, director of the Geological Survey of Sweden.

About 200 attended the International Mining Congress at Salt Lake City last July. The meeting was scarcely international except in name. The next congress will be held in Milwaukee in 1899.

Dr. O. Seydel, lecturer on osteology in the University of Amsterdam, well known for his researches on the Organ of Jacobson, has resigned and returned to Germany.

Lionel S. Wiglesworth, having completed his work on the birds of Celebes, has resigned his position as assistant in the zoological museum at Dresden.

Those familiar with the Academy of Natural Sciences of Philadelphia know how deeply it is indebted to the late Joseph Jeanes and his brother. His sister, Miss Anna T. Jeanes, has recently given the academy $20,000, the income to be used for museum purposes.

The following appointments have been announced: Dr. Cleveland Abbe, Jr., professor of geology in Western Maryland College. — N. Andrussow, professor extraordinarius of geology and paleontology in the University of Dorpat. — Dr. F. J. Becker, of Prag, professor of mineralogy in the University of Vienna. — Dr. Johannes Behrens, extraordinary professor of botany in the technical school at Karlsruhe. — Dr. Max Blanckenhorn, of Erlangen, assistant on the Geological Survey of Egypt. — Dr. Böhmig, professor extraordinarius of zoology in the University of Gratz. — Herbert Bolton, of Manchester, curator of the museum at Bristol, England. — Dr. A. Bühler, privat-docent for anatomy in the University of Würzburg. — Prof. Ladislaus

Celakowsky, director of the newly established botanical gardens of the Bohemian University of Prag. — H. C. Chadwick, curator of the biological station at Port Erin, Isle of Man. — Miss Agnes M. Claypole, assistant in histology and comparative anatomy in Cornell University. — E. G. Coghill, assistant in biology in the University of New Mexico. — Dr. Carl Isidon Cori, professor extraordinary of zoology in the German University of Prag, and director of the zoological station at Trieste. — Dr. Friedrich Dahl, assistant in the zoological museum in Berlin. — R. A. Daly, instructor in physiography in Harvard University. — M. Demoussy, assistant in vegetable physiology in the museum of natural history of Paris. — Paul A. Genty, director of the botanical gardens of Dijon, France. — Miss Gertrude Halley, demonstrator of anatomy in the University of Melbourne. — Dr. R. A. Harper, professor of botany in the University of Wisconsin. — Mr. J. H. Holland, curator of the botanic gardens at Old Calabar. — Dr. Z. Kamerling, assistant in botany in Munich. — Dr. Georg Karsten, professor extraordinarius of botany in the University of Kiel. — Dr. Georg Klebs, of Basel, professor of botany in the University of Halle. — Gregorius A. Kogevnikoff, privat-docent for zoology in the University of Moscow. — Dr. Fr. Kopsch, privat-docent for anatomy in the University of Berlin. — Dr. Kriechbaumer, curator of the zoological collections at Munich. — Dr. P. Kuckuck, custodian of the botanical collections of the Biological Institute of Heligoland. — Dr. Willy Kückenthal, of Jena, professor of zoology in the University of Breslau as successor to Carl Chun. — Dr. W. Kulczycki, privat-docent for zoology in the University of Lemburg. — Prof. E. Ray Lankester, of Oxford, director of the British Museum (Natural History), South Kensington. — A. Lawrski, privat-docent in mineralogy in the University of Kazan. — F. S. Maltby, assistant in bacteriology in the University of New Mexico. — Dr. Heinrich Monke, of Breslau, collaborator in the geological office in Berlin. — Dr. C. C. O'Harra, professor of geology and mineralogy in the South Dakota School of Mines. — N. Th. Pogrebow, secretary and librarian of the geological committee of St. Petersburg. — Georges Pruvot, of Grenoble, chief of the department of practical and applied zoology in the University of Paris. — Prof. Alfred Elias Törnebohm, director of the Swedish Geological Survey. — Dr. Ernst Vanhöffen, assistant in the zoological institute at Kiel. — A. Vayssiere, professor of agricultural zoology in the faculty of sciences at Marseilles, France. — John Vinezielt, assistant professor of biology and director of the bacteriological laboratory in the University of New Mexico. — Dr.

Benno Wandolleck, assistant in the zoological museum in Dresden. — Dr. A. Zalewski, privat-docent for botany in the University of Lemburg.

We regret to announce the following deaths: August Assmann, student of Lepidoptera, at Breslau. — E. B. Aveling, assistant in physiology in the University of Cambridge, aged 47. — Dr. Victor Becker, anthropologist, at Oudenbosch, Holland, February 10. — Dr. Eduard Albert Bielz, in Hermanstadt, Germany, May 26, aged 72 years. — Dr. Paul Brocchi, zoologist, at Paris. — Dr. Ernest Candèze, student of the Coleoptera, in Glain, Belgium, June 30. — Ferdinand Julius Cohn, professor of botany in the University of Breslau since 1859, June 25, aged 70 years. — J. Gallois, entomologist, at Déville les Rouen, France. — Dr. Carlo Giacomini, professor of anatomy in the University of Turin, July 5. — Samuel Gordon, zoologist at Dublin, April 29, aged 82. — Mariano de la Paz Graells, entomologist and professor of comparative anatomy in the University of Madrid, February 13, aged 80. — Rev. Walter Gregor, zoologist, near Aberdeen, Scotland. — Dr. Gümbel, geologist, at Munich, June 18, aged 75. — James I'Anson, mineralogist, at Darlington, England, March 30, aged 53. — Joseph Jemiller, student of Hymenoptera, in Munich. — Anton Kerner, professor of botany in the University of Vienna. — Prof. Leopold Krug, botanist, near Berlin, April 5, aged 63. — Dr. Johan Lange, botanist, and formerly director of the botanical gardens at Copenhagen, April 3, aged 80.

Doubtless some of our readers will be interested to learn from our advertising pages that extras of many of the papers of the late Professor Cope have been placed on sale. No one has done so much work and such good work upon the American vertebrates, living and fossil, as he; and his papers are absolutely necessary for the student of these forms.

PUBLICATIONS RECEIVED.

ACLOQUE, A. Faune de France. Thysanoures, Myriapodes, Arachnides, Crustacés, Nemathelminthes, Lophostomes, Vers, Mollusques, Polypes, Spongiaires, Protozraires. Paris, J. B. Baillière et Fils, 1898. 300 pp., 1664 figs., 12 mo. — BUTLER, A. W. The Birds of Indiana. From *Twenty-second Report of the Department of Geology and Natural Resources of Indiana.* 1187 pp., 8vo. — FAIRHURST, ALFRED. Organic Evolution Considered. St. Louis, Christian Pub. Co., 1898. 386 pp., 12mo, $1.50. — FISH, PIERRE A. Practical Exercises in Comparative Physiology and Urine Analysis. Ithaca. Published by the author, 1898. 71 pp., 75 cts. — GEGENBAUR, CARL. Vergleichende Anatomie der Wirbelthiere mit Berücksichtigung der Wirbellosen. Erster Band. Einleitung, Integument, Skeletsystem, Muskelsystem, Nervensystem und Sinnesorgane. Leipzig, Wilhelm Engelmann, 1898. xiv + 978 pp., 8vo, 619 ills., Marks 27. — MILLS, WESLEY. The Nature and Development of Animal Intelligence. New York, Macmillan Co., 1898. xii + 307 pp., 8vo, $2.00. — ROWLEY, JOHN. The Art of Taxidermy. New York, Appleton, 1898. xi + 244 pp., 8vo, 29 plates and 59 text-drawings.

Boletin del Instituto Geologico de México. No. 10. Bibliographia geologica y minera de la Republica Mexicana, 1898. — *Bulletin of the Geological Institution of the University of Upsala.* Vol. iii, Pt. 2, No. 6, 1897. Upsala, 1898. — *Bulletino del Laboratorio ed orto Botanico R. Universita degli Studi di Siena.* Ann. I. Fasc. 2–3, June, 1898. — *Geographical Magazine.* Vol. xii, Nos. 2, 3, August and September. — *Journal of the College of Science, Imperial University of Tokyo, Japan.* Vol. x, Pt. 3. GOTO, S. The Metamorphosis of Asterias pallida, with Special Reference to the Fate of the Body-Cavities. Vol. xii, Pt. 1. JACOBI, A., Japanische geschälte Pulmmaten. May, 1898. — *La Nuova Notarizia.* Serie ix. September, 1898. — *Memorias y Revista de la Sociedad Cientifica "Antonio Alzate."* Tome xi, Nos. 5–8. Mexico, 1898. — *Proceedings Biological Society of Washington.* Vol. xii, pp. 157–170, August 10. BANGS, O. On Some Birds from Pueblo Viejo, Columbia; Descriptions of Some New Mammals from the Sierra Nevada de Santa Marta, Columbia; a New Race of the Little Harvest Mouse from West Virginia. PREBLE, E. A. Description of a New Weasel from the Queen Charlotte Islands, B. C. — *The Insect World.* Vol. ii, No. 6, June, 1898. Zifu, Japan. — *University of Kansas, Experiment Station, Sixth Annual Report of the Director.* Contagious Diseases of the Chinch Bug. Lawrence, May, 1898. *Zoologist.* Nos. 685, 686, July, August.

(Number 382 was mailed October 26.)

JAMES HALL.

From the "Scientific American."

THE

AMERICAN NATUR

ERRATUM.

Through an oversight for which the author was not ı for Figs. 5 and 6 of Dr. Eastman's article on p. 766 of were interchanged. The lowermost figure is the do *Titanichthys clarkii* Newb., lacking the *carinal* in process, and is reduced $\frac{1}{18}$ instead of $\frac{1}{31}$ natural size.

tened attentively to verbally conveyed views, and could appropriate skillfully the results of labors not his own, when they fitted into the scheme of his laborious research. As a purely mechanical advantage, Hall evinced a literary superiority. His style is flowing and expressive, of much lucidity in language, and — simply because he was not an erudite or exhaustive thinker — attractively clear and intelligible in composition.

JAMES HALL.

From the "Scientific American."

THE

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RELATION OF JAMES HALL TO AMERICAN GEOLOGY.

L. P. GRATACAP.

PROFESSOR JAMES HALL may not be so good a geological delineator as W. W. Mather, nor so keen or so original a thinker in dynamical geology as E. Emmons, a less learned man than Lardner Vanuxem, and in no respect so accomplished a zoologist as T. A. Conrad ; yet the fame of James Hall will, meritoriously, far outrank the collective reputation of his four collaborators.

Hall was gifted with the power of generalization, a distinct talent to give territorial expansion to groups of separated observations, and to step outside of the limits of a conventional geological creed. And he possessed the faculty of assimilation. He derived important suggestions from previous research, listened attentively to verbally conveyed views, and could appropriate skillfully the results of labors not his own, when they fitted into the scheme of his laborious research. As a purely mechanical advantage, Hall evinced a literary superiority. His style is flowing and expressive, of much lucidity in language, and — simply because he was not an erudite or exhaustive thinker — attractively clear and intelligible in composition.

In Hall there was a distinct philosophical aptitude, sometimes evinced in remarks outside of the range of strictly scientific study, and this philosophical instinct led him into paths of induction which freed him from the bonds of stereotyped views in science itself. This *disquisitional* quality, as I venture to call it, is not inconsiderably shown in the opening pages of his "Preliminary Considerations" to the *Report on the Geology of the Fourth District*, in the same way that the pedagogical strain of his mind appears in the two or three succeeding chapters of the same work.

As illustrating both of these traits, under a somewhat oracular disguise, the following paragraph is of interest. It closes some remarks made upon the absence of the coal formations in New York State, for whose fancied presence money and labor had been unavailingly expended in exploration :

"It is thus negatively, as well as by direct and positive discoveries, that science ameliorates the condition of mankind; turning attention from useless and visionary pursuits, and directing it to that which yields a ready and satisfactory result for the expenditure of labor and time. And although the promulgation of scientific truths may restrain the vagaries of minds which delight to build the splendid air castles of suddenly acquired wealth, it will, nevertheless, direct man's energies to sources where perseverance is sure to be crowned with rewards which a morbid fancy would crave at the commencement of the enterprise. From science alone will man learn his true interests as regards his well-being in the world."

It was the philosopher in Hall which led him along the lines of wide conclusions so favorably and notably shown in the introduction of vol. iii of the *Paleontology of New York*. Here, as Walcott once remarked to the writer, "the substantial worth of Hall as a geological writer is fully illustrated," for in these ninety-six pages he sketches with considerable mastery at least, the relations of the palæozoics in the east, points out the misleading assumption of a Taconic system, and projects the theory of troughs of sedimentation as essential causes of mountain-making, a theory he had before laid before the scientific world in the *Proceedings of the American*

Association for the Advancement of Science. It was the philosopher in Hall which as early as 1839 or 1840 led him to instinctively enlarge and multiply the observations of Vanuxem, published in 1829, upon the identity of western formations with those of New York. It was the philosopher in Hall which saved him from Eaton's mistake in applying Wernerian categories to the New York rocks, and caused him to sweep the cobwebs of imitation and preconception from his eyes as he read the story of geological succession in their strata. He corrected the "distortion" (as he expressively termed it) which had made the even bedded layers of western New York equivalents of the so-called "secondary" rocks abroad, and discarded the illusion of an exact resemblance in the geology of Europe and America.

But this philosophic endowment did not endanger his physical activity. Less poetic and distinguished in mind or temperament than the Professors Rogers, his tireless curiosity and enthusiasm brought him in contact with a wider range of geographical and geological facts. He traveled extensively and made the results of his experience and his collections bear upon the elucidation of the geology of New York State.

It was fortunate that a philosophical mind, one addicted to comparison and induction, and not gifted either with marked scholarship or originality, should have been committed to the task of studying a section (the Fourth District) of the state where the succession was almost undisturbed, where leaf upon leaf, with contents unobliterated, the geological record, waited for its reader. Hall read the record and established the *pagination* of the opening sections of the Book of Geology for America. Imbued with lasting impressions of a quiet and continuous progress of deposition, marked by no more extreme perturbations than the secular rising and falling of the earth's crust, he became a strict Uniformitarian, and the problems of volcanic geology, which lay far outside of his path, seldom or never enlisted his attention. He writes in the *Geology of the Fourth District* (p. 10) : "The doctrine of violent catastrophes, and of sudden changes in the inhabitants of the ocean, was based upon the examination of limited districts, where the

entire series of deposits had never existed, or had been subsequently obliterated. And gradual and tranquil as the changes now seem to us, they may appear infinitely more so when a perfect sequence among the strata of the whole globe shall become known — when a *complete* succession shall be established from the oldest to the newest rock. From what we now know, compared with the knowledge existing a few years since, we can readily infer that some distant places, or even nearer localities, may furnish links now wanting in the chain." Hall's phenomenal vitality carried him through a period of geological research in which some of his expectations were verified.

The Fourth District, extending from Chautauqua and Niagara on the west to Wayne and Chemung on the east, was practically fully deciphered by Hall in its intrinsic stratigraphy, though the exact and complete outline of its formations has only recently been mapped. This region, so uniformly constructed, and referring so perspicuously to its origin in just such conditions as prevail along the margins of existing continents, appealed strongly to Hall's logical temperament. He writes of it :

"The analogy to recent formations is thus more fully seen; for we have precisely the same materials, differing only in degree of induration. We have the unaltered monuments of a widespread ocean teeming with life, and we find recorded its changes through vast periods of time. We now learn what were the conditions of its bed at these successive periods, and also what different characters it presented at distant points. The varying forms of its inhabitants are as well marked and as perfectly preserved as the recent species amid the mud and sand and pebbly bottoms of our present seas. The geographical limits of certain genera and species are as well defined in that primeval ocean as in the present; and, as now, upon the same bottom, we find in some places great accumulations of organic forms, while in others they are rare or wanting. Like our present ocean also, we know that this ancient one was agitated by winds and moved by tides; the drifted shells and comminuted corals tell us plainly of waves and currents, while in other places the fine sediment and equally distributed organic

remains speak either of a quiet sea or deep water, where they were placed beyond the tumult that might have raged nearer the surface."

Hall's study of this succession, and the generally increasing thickness of deposits to the east along the Appalachian uplift, his generalizations upon the continuity of these beds westward, and his growing realization of successions of fauna, with more or less clear appreciation of local variations in fauna, were resumed in the interesting and able introduction to vol. iii of the *New York Paleontology* (1859). The fact of the preponderant accumulations of sediment along the Appalachians had been reviewed and studied by him with an increasing certainty of divination that the association of these heavy deposits with the mountain chain itself was in the nature of a causal connection.

Hall had apprehended with his usual power of appreciative insight the dissertation of Herschel on the mobility of the earth's crust, and it was an exhibition of hermeneutics in geological science which read into the facts of the Appalachian tumulus the specific applicability of the suggestion. Here he saw a continental ridge made up of sedimentary rocks, twisted and folded, to be sure, and showing the results of powerful compression. But the mass, the vast aggregate of its limestones, slates, and sandstones, was sedimentary, and these deposits were evidently concentrated along a meridional crease, a trough or depression secularly raised and lowered. This path of sedimentation against and over an oscillating shore line provided the material, when raised, for a mountain chain. The trough was itself an inverted mountain ridge, and nowhere else was there such an adequate supply of *mass* to create an imposing elevation when lifted. As Hall succinctly said: "At no point, nor along any line between the Appalachian and Rocky mountains, could the same forces have produced a mountain chain, because the materials of accumulation were insufficient; and though we may trace what appears to be the gradually subsiding influence of these forces, it is simply in these instances due to the paucity of the material upon which to exhibit its effects. The parallel lines of elevation, on the west of the

Appalachians, are evidenced in gentle undulations, with the exception of the Cincinnati axis, which is more important, extending from Lake Ontario to Alabama, and is the last or most western of those parallel to the Appalachian chain."

It does not appear clearly that the physical consequences of his views were ever elaborated in his own mind, or that the thermal features of the problem, as somewhat narrowly presented by T. Mellard Reade, were studied. Indeed, there is discernible in Hall's writing a shrinking from the reference of mountain topography to dynamical agencies, but a quick response of interest to their indications of sculpture by erosion. If we might venture a pleasantry, we should say that if Professor Hall, as *deus ex machina*, had been permitted to have his own way, the Catskill rather than the Appalachian type of mountains would have been most widely distributed over the earth's surface.

Certain metamorphism and folding were recorded, and the contrasted phases of mountain-making exhibited in the Catskills and the Appalachians pointed out, but the metamorphism and folding were referred to the consequences of *weight* and not to crustal shortening. Here again Hall was quick to respond to contemporaneous investigation. He recognized that the facts of metamorphism did not require an enormous heat, and hinted at those hydrothermal processes which lithologists now find so active and efficient in producing mineral alteration. He says: "We must therefore look to some other agency than heat for the production of the phenomena witnessed; and it seems that the prime cause must have existed within the material itself, and that the entire change is due to motion, or fermentation and pressure, aided by a moderate increase of temperature, producing chemical change."

The view of mountain-making propounded by Hall was an illustration of common sense illumined by thought and observation. Yet it was in the nature of a revelation. Le Conte has told us "the idea was so entirely new, so utterly opposed to prevailing views, that it was wholly incomprehensible even to the foremost geologists. There was no place in the geological mind where it could find lodgment. It was curious to observe

the look of perplexity and bewilderment on the faces of the audience. Guyot was sitting immediately behind me. He leaned forward and whispered in my ear, 'Do you understand anything he is saying?' I whispered back, 'Not a word.'" This was scarcely a reflection on the intonation of the reader, but a truthful picture of mental consternation. Yet physico-chemical and mathematical obscurities could hardly be expected from Hall. The promulgation of his theory of mountain-making evinced and was the result of the instinct and experience of a stratigrapher.

It is impossible to read the dignified reports of the first, second, third, and fourth districts, strong and copious contributions to geology at a period in our scientific life when, except for differential or sporadic work at the hands of Eaton, McClure, and Featherstonhaugh, and more consecutive efforts from Jackson, Hitchcock, Troost, Percival, and Owen, nothing had been done in geology of commanding excellence — except the great work of the Professors Rogers — it is impossible to read these productions without being struck with the literary smoothness and the mental solidity of the *Report on the Fourth District*.

Here the pervading skill of presentation admirably expresses the geological simplicity of the facts. But the care and beauty of demonstration are happily united with suggestion. At one point we are invited to consider the varying rates of deposition for fine or heavy sediments, at another the character of shore and off-shore deposits, here the mechanics of river erosion are discussed, and there the alternating velocity and slowness of tides. We ponder on the changing colors of strata and what they mean, or are made to feel by some analogy how real those ancient beaches and ocean beds were. We are carried across Lake Ontario, and shown the Laurentian base of our system upon which in shelving order the later formations lie, appearing on the southern borders of the lake as the Upper Silurian; and the realization of this is made distinct and memorable.

Hall's relation to American geology is that of the *illuminator*. He presented a broad, intelligible proposition, and on its basis a mass of evidence fell into discrete symmetry. Such was the succession of overlapping strata, their encircling lines

of deposition around an interior basin, the Taconic system as a changed Silurian system, mountains as rock heaps, faunal categories, and cycles.

This illuminating power was indeed due to a certain plainness in Hall's mind that led him to reject arduous and difficult theories. And it led him on the straight sunlit path when a more abstruse mind would have been, with great effort, working away from the truth underneath the ground. The work of correlation of the fossil horizons of the United States, done by Hall, was largely based upon fossil evidence as well as topographic continuity, and this correlation personally established by himself, as it was more and more supported by fresh evidence and new workers, laid bare the simplicity of the geology of the east and middle United States.

Indomitable in desire as he was in spirit, Hall reached the Rocky Mountains and established some of the first identifications of the Cretaceous in the west, and had begun there to show its varying character.

It belongs to the sensibleness of the man, the quality that often in other walks of life is the boon and the compensation of mediocrity, that Hall exercised a conservative influence in the terminology of the New York system. The names used by the New York geologists for the palæozoic formations remain, and are now printed as indelibly in memory as they are in books. They carry with them no euphonic distinction. They are not made educationally suggestive. They are eminently commonplace, and their *raison d'être* is absolutely obvious. Potsdam, Chazy, Calciferous, Black River, Trenton, Utica, Hudson River, Clinton, Medina, Niagara, and the rest are all place names easily understood, easily remembered, and have been easily applied to beds at localities most remote from all of them. Plain men like them, and scholars, have not replaced them by anything more refined. In this respect geology has both set and followed this example.

It belonged to the logic of Hall's mind and a certain original fixity of idea in him to combat Emmons' Taconic System. He rejected the injection of a new series of horizons. It complicated matters, and Hall shrank from enigmas. He looked upon

the schists, slates, and marbles of the green hills of Vermont as altered silurian sediments, and it has been the great distinction of the present Director of the United States Survey to prove this.

The same investigator has also vindicated the term "Hudson River" as embracing the section from the Trenton to the overlying Upper Silurian rocks, enclosing the Utica, a term instituted by the New York geologists, and more narrowly defined by Hall, though at first somewhat resisted by him.

Certainly to the far wider audience of scientific readers Hall stands as the embodiment of paleontological prestige. The enormous publications of the New York Survey, their later resplendent illustration, and the numerous dissertations and contributory essays on genera, families, morphology, and distribution of fossils, found in the *Reports of the New York State Cabinet*, have fixed the eye of attention upon Hall as a zoologist.

In no real sense was Hall a zoologist. His actual acquaintance with animal life was slight, and his system and habit of arrangement entirely mimetic. Certainly an enthusiastic and contemplative mind could hardly have escaped distinction in bringing to light the rising series of fossil forms which the regular succession of rocks displayed. Hall handled the retinue of forms thus presented with signal success. His work at first was tentative, but became increasingly valuable, especially as the influence of two great works educated his perception, and the influence of more acute zoologists, employed as his assistants, directed his discernment.

The formative influences of the Canadian Survey and Barrande's *Système Silurien* are plainly discernible in the progressive improvement of the *Paleontology of New York*. The Canadian Survey, with which for a short time he was connected, brought him into contact with a new field of fossil exploration, and he felt the stimulation of Sir William Logan as a helpful factor in his studies. The preparation of the decades and his close analysis of the graptolitic fauna were distinct advances over his former work in paleontology, wherein also it can hardly be denied that the extraordinary morphological instinct of Whitfield played a beneficial part. And in

Canada, besides the graptolites, the development of Crinoids and Cystids revealed a strange aspect of fossil life, repeated in the Niagara limestone of New York.

In Barrande's *Système Silurien,* a great work, exhaustively executed, Hall found strongly accentuated the fact of faunas and colonies, and the impression made by that work indorsed his own views and deepened them. Hall was not a thorough-going evolutionist, and Barrande's feelings about fixed types effected a permanent lodgment in Hall's zoological creed.

Hall's sanity, his reasonableness and restraint, is shown in his paleontological work, and reflects the sort of clarity of mind which distinguished his geological research. His literary instinct appears in his names also, which are pronounceable, well composed, and significant. His diagnosis of species and genera seemed remarkably correct. It was much later than his first work that he yielded to the solicitations of the hour and poured out species and genera so devotedly; sometimes it is to be feared with a desire to obscure previous publications. Hall's diagnosis of Eurypterus, for instance, was admirable, though indisputably much of its perspicacity was injected from the careful comparative studies of Whitfield with Limulus. Agassiz, as is well known, coincided with these views.

The idiosyncrasies of Conrad, his unstudiousness, his carelessness and laconic methods, despite his genius in recognizing form, placed Hall's work at a surpassing distance beyond him. The appearance of the first two volumes of the *Paleontology of New York*, which were distinctively and, so to speak, indigenously Hall's work, marked a real epoch in scientific publication in this country. The wave of excitement spread abroad, and the keenest expectation was excited by the possibilities of a field of research, almost untouched, from which light might be expected upon the problems of life, new and brighter than that afforded in the similar areas of Europe.

When de Verneuil assured Hall of the striking specific contrasts, as well as the specific identities with those of Europe, amongst the fossils he was displaying to the scientific world, the path seemed opened for indefinite additions to the sum of knowledge in paleontology.

The consecutive arrangement of fossils from the various formations, their concentration in single volumes, the scale of illustration, all combined to give the publication a sort of encyclopedic character which, coupled with the promise of its continuous extension, made it a reference library of paleontology at that early day. It was continued, and as the finished and unexcelled drawings of Simpson and Whitfield, with the perfect lithography of Ast, gave it greater and greater luster, it grew upwards into the proudest monument perhaps ever erected to an American geologist.

It is interesting to read these early volumes, the starting points of American paleontology, and note the comparisons and observations. The author, with his characteristic love of illuminating observation, notes the varying character of the same species in successive beds or differing localities, compares and elucidates species, dwells on identity or contrast with European species, points out eccentricities of structure or ornament. These early volumes have a temporary, almost a temporizing character, are provisional in statement and necessarily imperfect in execution. The prolixity, evolution, and circumlocution of Barrande's work, published almost at the same time, contrasts almost amusingly with Hall's adequate but by comparison meager treatment, and of course Barrande's figures are incomparable, if a trifle mechanical and stiff. But Hall explains his own great difficulties — his small library, his distance from scientific friends, without authentic collections for comparison, in a new field, and with poor facilities for illustration. These impediments passed away. It is a part of that history of the development of paleontological science to note that at Albany was created a center of attraction and radiation, and two men became enlisted in this work whose special powers entered as determinative forces in its improvement — Whitfield and Meek. Later a higher stage even of erudition was reached, and Clarke and Beecher completed the assumption of the advanced biological expression.

What a development of scientific work in his own chosen field Professor James Hall has seen! State surveys and the marvelous rise of the government surveys started up around

him, while the new energies of exploration and the deepened currents of study and insight ushered in our modern period with its exuberant hair-splitting and interminable terminologies.

Professor Hall is dead. Contest and contestant sleep in one grave. There lives above it the imperishable memory of an enthusiasm and a devotion which began the most glorious chapter of scientific progress in America.

THE WINGS OF INSECTS.

J. H. COMSTOCK AND J. G. NEEDHAM.

CHAPTER IV (*continued*).

The Specialization of Wings by Addition.

III. THE VENATION OF THE WINGS OF ODONATA.

THE wings of dragon flies have furnished the best of systematic characters since the days of Linnæus. The many peculiarities of venation have been slowly worked out and expressed in a formidable system of terms, most of which designate parts bearing other names in other orders. Indeed, this is not strange;

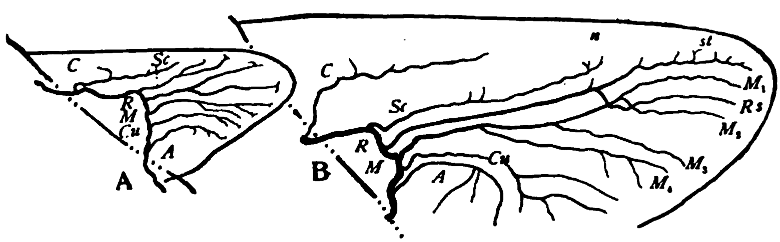

FIG. 60. — Wings of nymphs of *Gomphus descriptus*, early stages.

for, from the study of the adult wings alone, the discovery of the real homologies would be well-nigh impossible.

The richly veined wing of a dragon fly, at first sight, shows little in common with our hypothetical type. And even when the tracheation of the wing of an old nymph is studied, there are found some striking discrepancies. But in the budding wing of a young nymph we find an arrangement of the tracheæ which is almost that of the typical wing.

Fig. 60 represents the tracheation of two nymphs of *Gomphus descriptus*. The wing figured at *A* was only 1 mm. in length. Here is a costa with some anterior twigs, a subcosta with a terminal fork, a radius with its sector unbranched, a three-branched media, a cubitus which is two-branched in the usual

way, and a single anal vein with three branches, which may represent the three anal veins, fused at the base.

At *B* (Fig. 60) is represented the tracheation of a somewhat older wing, one measuring 3 mm. in length. Here the radial sector has shifted its position and lies across the end of the media, the terminal portion of it lying between M_1 and M_2. The media is now four-branched. The costal and anal tracheæ

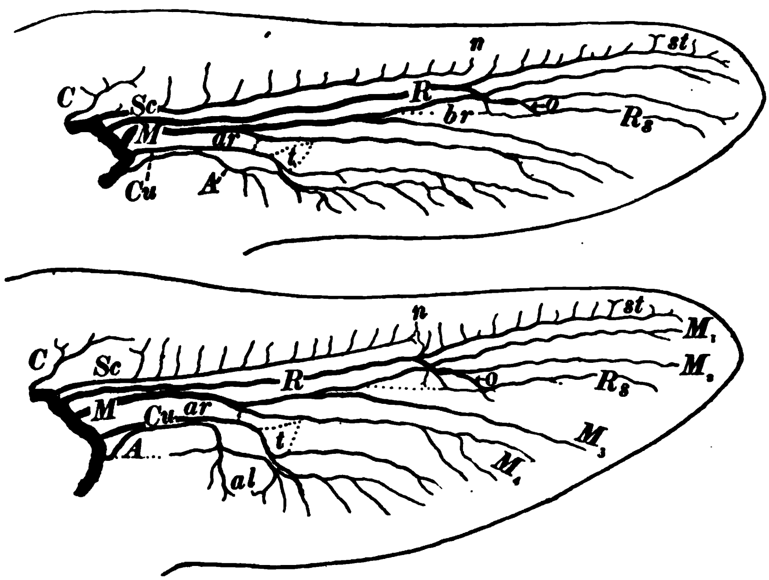

FIG. 61. — Fore and hind wings of a nearly grown nymph of *Cordulegaster diastatops*, showing tracheæ. *n*, nodus; *st*, stigma; *o*, oblique vein; *br*, bridge; *ar*, arculus; *t*, triangle; *al*, anal loop. The permanent venation which shows distinctly at this stage is omitted, except where indicated by dotted lines at the bridge, arculus, and triangle.

are outrun by the others in the occupation of the new territory formed by the growth of the wing, and remain relatively short.

In the wings of a grown nymph (Fig. 61) is seen the culmination of these tendencies. The radial sector has completed its migration and lies in its final position, the terminal portion traversing the area between M_2 and M_3. The costa is greatly reduced or, rather, outstripped by its competitors; the same is true in a less degree of the subcosta and the anal vein. At this stage the veins, which are not represented in the figure, appear as pale, brownish thickenings; surrounding all of the

principal tracheæ, and also surrounding the anastomosing tracheoles, which tend to group themselves in the positions of the cross-veins.

The most anomalous thing seen here is the position of the radial sector, a character which is quite distinctive of this order. In the adult wing (Fig. 62) this sector appears to be a branch of the media, and it has always been so interpreted. The only indication of its connection with the radius is the persistent obliquity of an apparent cross-vein between veins M_2 and R_s, just beyond the nodus.

The crossing of these tracheæ (Fig. 61) was first figured

FIG. 62. — Adult wings of *Cordulegaster sayi*, lettered as in Fig. 61.

(incidentally) by Roster;[1] later it was described and discussed by Brauer and Redtenbacher;[2] and it was again figured and described by Brogniart.[3] But the effect of this crossing upon the homologies of the veins seems to have been overlooked. The apparent cross-vein is, in fact, a part of the radial sector; the longitudinal trunk connecting the sector with the media is not homologous with any of the principal veins, but is a secondary structure, developed for mechanical advantage, and the radial sector itself should be so termed, notwithstanding it appears to be a branch of the media and is far removed from

[1] Roster, D. A. *Bull. Soc. Ent. Ital.*, vol. xvii (1885), Pl. IV.

[2] Brauer u. Redtenbacher. *Zool. Anz.*, Bd. xi (1888), pp. 443–447.

[3] Brogniart. *Recherches sur les Insectes Fossiles* (1894), pp. 204–208, Pl. VIII.

its usual position. It will be convenient to designate that part of the radial sector which appears as a cross-vein behind vein M_2 as the *oblique vein* (Fig. 62, *o*); and the secondary longitudinal trunk as the *bridge* (Fig. 62, *br*).

In the adult wing the bridge exhibits no evidence of an origin different from that of the radial sector, with which it is strictly continuous. But a study of the tracheation of the

FIG. 63.—The region of the nodus in *Anax junius*, showing the crossing of the radial sector and the origin of the trachea which precedes the bridge. *o*, oblique vein; *br*, the bridge.

wings of nymphs reveals the secondary nature of the origin of the bridge. Fig. 63 is a reproduction of a photograph of a portion of a wing of a nymph of *Anax junius*, showing the crossing of the radial sector, and the origin of the trachea which precedes the bridge. The latter is a small twig which arises from the distal end of that portion of the radial sector which becomes the oblique vein, and extends towards the base of the wing in a direct line to the media. This method of formation of the bridge is characteristic of the Æschnidæ.

In most Libellulidæ a trachea, or a bunch of tracheoles, descends from near the base of the radial sector and forks at the level of the bridge, one branch going to the distal end of the oblique vein, the other going in a diametrically opposite direction to the media (Fig. 64).

The illustrations just given exhibit the structure of these parts in nymphs of the suborder Anisoptera. In the suborder Zygoptera (Calopterygidæ and Agrionidæ) there exists a striking difference. If we compare adult wings of the two suborders, there can be no question as to the identity of vein R_s, or as to its homology in the two groups. But in the suborder Zygoptera, so far as known to us, the trachea R_s is a branch of the medial trachea. The base of R_s, however, forms an oblique vein, and a bridge is developed secondarily, as in the Anisoptera. It is probable that there has been a switching of the base of the trachea R_s from trachea R to trachea M. One has only to examine a well-mounted wing of any dragon-fly nymph to see in the universal anastomoses of tracheoles communications already set up between principal tracheæ, any one of which

FIG. 64.—The region of the nodus in *Libellula pulchella*. *o*, oblique vein; *br*, the bridge.

might be enlarged, should necessity arise for the entrance of air from a new quarter. Following this, the atrophy of the old connection would complete the switching; which, we believe, is what has happened in the Zygoptera. It follows from this that, so far as this portion of the wing is concerned, the Zygoptera depart more widely from the primitive type than do the Anisoptera. From this brief sketch it is evident that these parts will furnish systematic characters which are as yet unused.

For increasing its efficiency, certain methods of bracing the dragon-fly wing in its costal and basal parts have been perfected to a degree surpassing anything to be seen in any other order. The veins of the costal margin are thickened and approximated as usual; but the strong corrugation of the area traversed by them is maintained by their being bound together at the nodus, at the stigma, and often toward the base, where certain of the antenodal cross-veins become greatly thickened. These hypertrophied antenodals sometimes (as in Æschna) become stout triangular trusses which completely fill, in section, the furrow between the costa and the radius. Toward its base, the wing is braced by two characteristic structures well known in the literature of the Odonata as the *arculus* and the *triangle.* The arculus has already been discussed.[1]

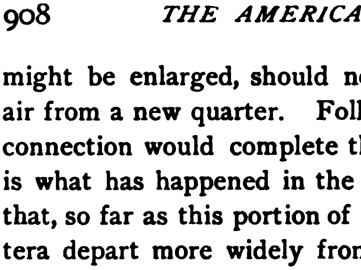

FIG. 65.— Diagram setting forth the behavior of the triangle in the suborder Anisoptera. The heavy lines bound a somewhat primitive triangle. 2, 3, 4, and 5 are stages in the descent of the upper cross-vein which are to be seen in such living genera as Tetrathemis, Anatya, Libellula, and Tetragoneuria, respectively. 1′, 2′, 3′, and 4′ represent successive stages in the retraction of the cubitus at the triangle, stages seen in the fore wings of Microdiplax, Anatya, Sympetrum, and Perithemis, respectively. 1″, 2″, 3″, and 4″ represent stages in the retraction of the base of vein Cu_2 as seen in the fore wings of Orchithemis, Anatya, Libellula, and Tetragoneuria. 1‴, 2‴, 3‴, and 4‴ represent stages in the ascent of the vein Cu_1 up the outer side of the triangle, stages seen in the hind wings of Ladona, Mesothemis, Anatya, and Nannodythemis.

The Triangle. — The deflection of the cubital trachea, just before its fork, makes a place for the development of the triangle. This is one of the most important features of the wings in the suborder Anisoptera, to which alone the following remarks will apply. While its stout bound-

[1] *American Naturalist,* vol. xxxii, No. 376, p. 234, Fig. 7.

aries unite strongly the three posterior longitudinal veins, only its inner side is bounded by a principal vein, its anterior and outer sides being formed from two cross-veins approximated upon vein M_4. Primitively it differed little from an ordinary rectangular cell. The accompanying diagram (Fig. 65) shows the successive positions assumed by its anterior and inner sides

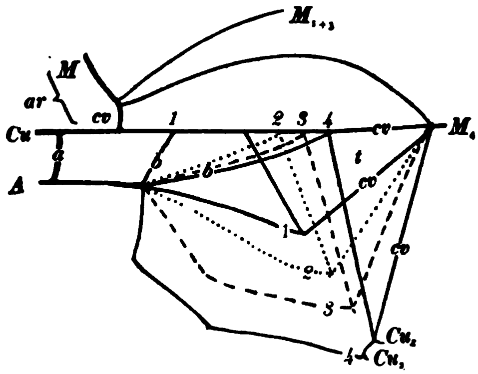

FIG. 66. — Diagram illustrating the procession of the triangle, and the deflection of the second Cu-A cross-vein in the fore wings of Libellulidæ. *a*, the first, and *b*, the second Cu-A cross-veins; 1, 2, 3, and 4, successive positions.

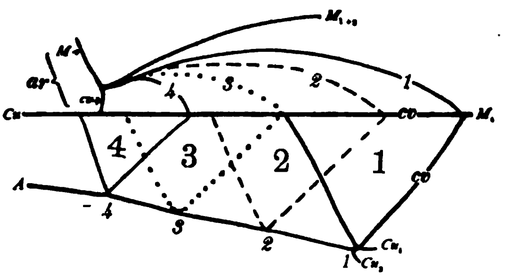

FIG. 67. — Diagram representing the recession of the triangle in the hind wings of the Libellulidæ. 1, 2, 3, and 4, successive stages.

and by the two branches of the cubitus at their departure from it. This epitome of its history presents only steps in its development that are still preserved in the wings of living genera.

In the Libellulidæ differentiation between fore and hind wing has changed the relation between arculus, triangle, and anal vein. Doubtless these were once similarly placed in the two wings, the triangle being a little beyond the arculus, and the anal vein meeting its hind angle in both wings (as, for

instance, at present in Cordulegaster). In the fore wing the anal vein has come to connect with the antero-internal angle of the triangle through the deflection of the second cubito-anal cross-vein, and the triangle has proceeded farther from the arculus. Successive steps are shown in the accompanying diagram (Fig. 66). In the hind wing the triangle has receded to the level of the arculus, or even a little farther, by the easy stages shown in the accompanying diagram (Fig. 67), and the second cubito-anal cross-vein has atrophied.

The Anal Loop. — There is also in the Anisoptera a strong tendency toward the development in the hind wing of a broadly expanded anal area — an aëroplane. This region remains still

FIG. 68. — Forms of the anal loop in the Anisoptera: 1, anal loop of *Cyclophylla diphylla*; 2, of *Gomphoides stigmatus*, 3, of *Gomphaeschna furcillata*; 4, of *Gomphomacromia paradoxa*, 5, of *Syncordulia gracilis*, 6, of *Agrionoptera insignis*, 7, of (?) *Nannophya maculosa*, 8, of *Ephidatia longipes*, 9, of *Hydrobasileus extraneus*.

unexplored territory. It will furnish, however, at least one character of much systematic importance. This is a space included between the first and second principal branches of the anal vein, which we designate as the ***anal loop***. Its development is shown in Fig. 61. When developed in the Æschnidæ as a distinct enclosure, it is always compact in form, but in the more specialized of the Libellulidæ it becomes elongate, then gland-shaped, and then foot-shaped. Fig. 68 shows its more characteristic forms, and gives an idea of its variability within the group.

We have now indicated the homologies of the principal veins: we have briefly discussed the development of a few of the distinctive venational characters of this interesting group;

there is not space for details, but these are the less necessary because the junior author will shortly publish elsewhere an extended paper upon the venation of this order. It may be remarked, however, in passing, that the tendency throughout the order is toward vein multiplication. Additions are made upon both sides of several principal branches, and they conform to no one simple type. These new branches are preceded by tracheæ; but there are other interpolated veins developed for mechanical advantage quite independently of the tracheæ and cutting across them.

The radial sector is unique in form as well as in position.

All the peculiarities of this intricate venation have arisen out of the necessity for making all the veins individually useful: and those dragon flies which have been most successful in differentiating between the added veins are among the fleetest of winged creatures.

VARIATION IN THE SHELL OF HELIX NEMORALIS IN THE LEXINGTON, VA., COLONY.[1]

JAS. LEWIS HOWE.

THE colony of *Helix nemoralis* at Lexington, Va., has attracted considerable attention on account of the large number of varieties found. It was first studied by Major J. H. Morrison, then connected with the Virginia Military Institute. A very considerable number of specimens was collected by him and described by T. D. A. Cockerell.[2] Major Morrison sent out quite a number of colonies of the snails, that their variations in other localities might be studied, but only one of these colonies has been heard from. Early in his studies Major Morrison removed from Lexington, and soon after his records and much of his collection were destroyed by fire; hence he has been prevented from pursuing the study of the colony. Up to this time one hundred varieties had been described.

Later Mrs. John M. Brooke became interested in the subject, and from her collections a number of new varieties were described by Professor Cockerell.[3]

Last summer (1897), becoming interested through Professor Cockerell, I collected a series ("*A*") of 1134 shells from my garden and that adjacent. The two premises, with a narrow alley between, covered an area rather over 200 feet square. The present summer (1898) I collected on the same ground a second series ("*B*") of 1000 shells, and also a series ("*C*") from the garden where the colony originated. This series numbered 1258 specimens.

The colony is doubtless correctly believed to have had its origin in 1883, with the return of Mrs. John Moore from a European trip. Mrs. Moore ascribes the colony to straw used in packing goods from Florence. It is not impossible that it may have come from earth around a collection of ivies. The

[1] Read at the Boston Meeting of the American Association for the Advancement of Science, August, 1898. [2] *Nautilus*, November, 1889; December, 1894.
[3] *Science*, N.S. 5 (1897), 985.

ivy was from Kenilworth, Abbotsford, and Dryburgh, and was packed in earth at Queenstown. The garden where the snails were first noticed is about 200 yards from my garden. They spread at first with considerable rapidity, but since the first few years their limits have widened only slowly. As far as I can learn, by examination and inquiry, they are confined to a territory not over one and one-fourth miles long and one-half mile wide.

My aim in collecting the three series, which I hope at some future time to supplement, was to get light on the following questions: (*a*) Does the tendency to variation proceed along certain definite lines, and if so, what? (*b*) Does this tendency vary in different localities in the colony? (*c*) Will a very considerable destruction of individuals modify materially this tendency? A study of these three series seems to give an affirmative answer to "*a*" and "*b*," and a negative answer to "*c*."

The succeeding tables, which summarize the results of these series, have reference solely to the *banding* of the shell; of series *A*, 87%, and of series *B*, 83% are var. *libellula* (with yellow ground). In series "*C*" every shell but one is *libellula*.

The formulæ used in designating the varieties are those which have of late been generally adopted, and for a knowledge of which I am indebted to Professor Cockerell. The typical shell of the Lexington colony, or at least the most common variety (*libellula*), has a yellow ground and five bands, three above the periphery and two (usually broader bands) below.

Shell of *Helix nemoralis*. The bands are numbered 1 to 5. The right-hand figure shows bands 4 and 5 only.

These are numbered from the top of the body whorl (near the mouth) downward 1 2 3 4 5, as shown in the accompanying cut. A band which is incomplete or appears only in traces, *i.e.*, rudimentary, is designated in the formulæ by a small number, as $1_{2}345$. A band which is wanting is designated 0, as in 10345. Obviously there will be every intergrade between the formulæ, as between 12345 and $1_{2}345$. In some European shells a band is interrupted at intervals, and for this a colon (:) is used, but these have not been noticed in Lexington. When two bands

are fused into one, they are enclosed in a parenthesis, as 123(45). In my lists a distinction is made in the order of fusion, thus [(12)(3(45))] indicates that bands 4 and 5 are first fused, then band 3 unites with this fused band (45), bands 1 and 2 are also fused, and finally all the bands are united into one. An x is used to denote a band which cannot be referred to any of the usual five bands; such bands are generally rudimentary, but in a few instances they are equally strong with the other bands, and then designated by X. A split band is marked by doubling the number if both bands are strong, as 122345, and by adding a small number if one of the bands is weak, as $12_{2}345$. In one case only a rudimentary band passes from one band to another, fusing first with one and then with the other; this is var. *libellula* $1(2^{(}x_{)}3)(45)$.

TABLE I.—FREQUENCY OF ALL VARIETIES OCCURRING MORE THAN FIVE TIMES.

(In percentage.)

FORMULA.	SERIES A.	SERIES B.	SERIES C.	FORMULA.	SERIES A.	SERIES B.	SERIES C.
12345	40.	41.1	31.6	120(45)	0.4	0.5	0.3
(12)345	0.7	0.6	0.7	$12_{3}45$	0.9	0.6	0.4
123(45)	12.3	10.5	17.2	$_{1}0345$	1.1	1.1	2.2
(12)3(45)	4.	4.4	5.2	$_{12}345$	0.6	0.5	2.9
(123)(45)	0.4	0.6	1.9				
1(2345)	0.	0.	0.5	00300	8.2	8.8	0.2
(12345)	0.4	0.1	0.8	0030_{5}	0.9	1.	0.1
[123(45)]	0.	0.	1.3	$003_{4}0$	0.5	0.5	0.
[(12)3(45)]	0.	0.2	0.6				
				00000	4.	2.6	5.
$_{1}2345$	1.2	0.9	3.1				
$_{1}23(45)$	0.3	0.6	1.5	$12_{x}345$	0.6	0.4	0.2
10345	6.	6.2	2.5	$123_{x}45$	1.1	1.3	0.9
$1_{2}345$	3.6	4.	3.7	$123_{x}(45)$	0.4	0.4	0.7
$1_{2}3(45)$	0.	0.2	0.5	$(12)3_{x}(45)$	0.3	0.2	0.5
				$(123)_{x}(45)$	0.2	0.	0.5
12045	1.3	2.	1.2				

Originally each variety was designated by a distinct name. Certain of these names are now used to designate the color of the type, and the banding is expressed by the formula. Thus *petiveria* was fawn and bandless, but the name is now applied

to all shells whose ground color is fawn, and the formula of each is added. Not only in formula, but also in color do the shells intergrade, and the personal equation in nomenclature is large. This, however, affects the deductions from large series but little. Great variation also appears in the width of the bands and to some extent in their color, but these distinctions have not been noted in this paper.

TABLE II. — FREQUENCY OF VARIETIES OCCURRING MORE THAN TWENTY TIMES.

(In percentage.)

	A.	B.	C.	D.		A.	B.	C.	D.
12345	40.	41.1	31.6	47.	12045	1.3	2.	1.2	3.9
123 (45)	12.3	10.5	17.2	14.6	$_{1}0345$	1.1	1.1	2.2	2.
(12) 3 (45)	4.	4.4	5.2	0.2	$_{12}345$	0.6	0.5	2.9	1.3
$_{1}2345$	1.2	0.9	3.1		00300	8.2	8.8	0.2	0.7
10345	6.	6.5	2.5	6.6	00000	4.	2.6	5.	4.6
$1_{2}345$	3.6	4.	3.7	5.9					

"*D*" is a series of 151 shells, sent by Mrs. Brooke to Professor Cockerell, and described in *Science*.[1] While not large, it shows the same general tendency as the other series, resembling "*A*" and "*B*" much more closely than "*C*." It is curious, however, that the series contained but one 00300, as this formula is frequent in Mrs. Brooke's garden. This series resembles "*A*" and "*B*" also in containing quite a number (4.6%) of other varieties than *libellula*.

In summing up Table II, we find that these eleven varieties comprise 82.3% of all the shells in series "*A*," and 82.4% of those in "*B*," but only 75.7% of those in "*C*." They also comprise 86.8% of "*D*." The great *scattering* of the variation is thus shown by the fact that in "*A*" 17.7% of the series contain 102 varieties; in "*B*" 17.6% contain 102 varieties, while in "*C*" 24.3% contain 127 varieties.

These series may be looked at from a somewhat different standpoint, as shown by the following table, in which the varieties are classified. Here the variation of a band may mean that it becomes rudimentary, disappears, or splits. It is doubt-

[1] *Science*, *loc. cit.*

ful if it be correct to put the splitting and the disappearance in the same category, but every method of classification offers difficulties.

Table III. — Percentage Frequency of Whole Series Classified.

The figures in parenthesis indicate the number of different varieties in each group.

	A.	B.	C.
12345	(1) 40.	(1) 41.1	(1) 31.6
12345, two or more bands fused	(9) 18.3	(13) 17.1	(22) 30.6
Band 1, variable	(2) 1.5	(2) 1.5	(5) 5.1
" 2, "	(6) 10.4	(6) 11.1	(10) 7.2
" 3, "	(8) 3.2	(16) 4.7	(22) 3.3
" 4, "	(4) 0.3	(2) 0.2	(4) 0.4
" 5, "	(1) 0.1	(4) 0.3	(2) 0.2
Bands[1] 1 and 2, variable	(5) 2.3	(7) 2.1	(7) 5.7
" 1 " 3, "	(1) 0.1	0.	(4) 0.6
" 1 " 5, "	0.	0.	(1) 0.1
" 2 " 3, "	(8) 1.3	(6) 0.9	(3) 0.3
" 2 " 4, "	(1) 0.1	(1) 0.1	(1) 0.1
" 3 " 4, "	0.	(1) 0.1	(1) 0.1
" 3 " 5, "	(1) 0.1	0.	0.
Three bands[2] variable	(9) 0.8	(6) 0.7	(6) 0.9
Four bands[3] variable	(10) 10.3	(5) 10.5	(2) 0.3
All five bands[4] variable	(3) 4.2	(8) 3.4	(1) 5.
Extra Bands With or Without other Variation.			
*x*12345	(2) 0.2	0.	(1) 0.1
1*x*2345	(1) 0.1	(1) 0.1	0.
12*x*345	(6) 1.5	(8) 1.5	(10) 1.8
123*x*45	(23) 4.2	(15) 3.4	(30) 5.6
1234*x*5	(4) 0.4	(5) 0.4	(1) 0.1
12345*x*	(1) 0.1	0.	0.
1*x*23*x*45	(1) 0.1	(1) 0.1	0.
12*x*3*x*45	(4) 0.4	(4) 0.4	(6) 0.5
12*x*34*x*5	0.	(1) 0.1	0.
123*x*4*x*5	0.	(2) 0.2	0.
1*x*2*x*3*x*45	(1) 0.1	0.	0.

[1] Variation in bands 1 and 4, 2 and 5, and 4 and 5 has not been found.

[2] Bands 123, 124, 125, 145, and 245. Single specimens of 234 and 235 variable are also known in the colony, but not in these series.

[3] All with 1245 variable, except two shells of 00005.

[4] Chiefly 00000.

Professor Cockerell has raised the question as to whether the colony, which at first showed a strong tendency to split-band varieties, may not be reverting to the European type, in which the split-band varieties are much less common. From information gathered from data furnished by Major Morrison, he estimates 100 split-band shells in a series of 2200, or about 4.8%. In Mrs. Brooke's list "*D*," the split-band forms are about 4%. In my own series the proportion is in "*A*" 4.4%, in "*B*" 4.1%, in "*C*" 3.4%. A large proportion of the variation in the Lexington colony is along this line. Of varieties previously enumerated, 52 out of 108, or 48%, are split-bands. Of the 277 new varieties listed in this paper, 112, or 40%, show a split band. It is rare to find two split-band shells alike; indeed, among the 134 split-band shells in my three series, no less than 112 different varieties are comprised. It is true that there seems to be a slight diminution in the proportion of split-band shells in the later series, but the diminution is small, and I do not know that Major Morrison's series was intended to be made up impartially. In any case the difference is less than the local difference between series "*A*" and "*C*." In my lists varieties with extra bands (*x* bands) are not counted as split-band. I do not know whether this was the case in Major Morrison's list.

One further table shows very strikingly the divergence of series "*A*" and "*B*" from "*C*."

TABLE IV. — RELATIVE FREQUENCY OF FUSED BANDS.

(By percentage.)

	A.	B.	C.	D.
All bands fused into one.	0.4	0.6	3.9	0.
Five banded shells with two or more bands fused .	18.3	17.1	30.6	17.9
All varieties with two or more bands fused	23.3	24.7	43.2	22.5

From these facts there are certain conclusions which may be drawn. While the variation is very "scattering," there is a predominance of tendency along certain lines. The most frequent variation is the fusion of bands 4 and 5. Bands 12 and 123 have considerable tendency to fuse, but band 3 rarely fuses with band 4 till all the other bands are fused.

Next to band fusion the most common variation is that of band 2, which varies in 10% of the shells. Band 3 is much less variable; band 1 but slightly variable, except in conjunction with band 2. (In series "*C*," band 1 almost equals band 2 in variability.) Band 4 and band 5 vary very rarely, except when four or all five bands disappear.

In series "*A*" and "*B*" 10% of the shells belong to the group where band 3 alone is left unchanged; these are chiefly 00300, and it is here the variety *rubella* is principally found. The plain shells, or those with only rudiments of bands, run about 4%, and show the chief color variations.

In all the above the tendencies of variation are similar to those in Europe, and the chief varieties are all known in Europe.

More peculiar is the splitting of bands already considered, and the presence of extra bands which cannot be ascribed to any of the common bands. Here the presence of a band between 3 and 4 is most frequent (about 4%), while a band between 2 and 3 is not at all uncommon. Other extra bands are very rare.

As regards variation in different localities, a decided difference is apparent. Little experience is needed to recognize a handful of the shells from Mrs. Moore's garden, their original habitat. The chief differences are three: (*a*) the almost complete absence of any variety except *libellula*. Series "*C*" contains one specimen of var. *rubella* 00300, and Mrs. Moore has in her possession three or four *rubella* 00000, which probably were picked up in her garden. I have seen nothing else from there except *libellula*. (*b*) The almost complete absence of formula 00300, which makes up about 10% in my garden and is very abundant everywhere else. (*c*) The great tendency to fusion of bands, as is shown by Table IV. It should be mentioned that a large proportion of the "*C*" shells seem to have been injured and repaired, and this seems to interfere with the development of band 1, and may account for the higher percentage of variation in band 1 of this series. No reason is apparent why shells from this locality should be more injured than those of other localities, and the injury may be only

apparent. The number of varieties in the "*C*" series is 139, and 113 in each of the other two.

As regards the effect of large destruction of the animals, little difference is apparent in proportions in series "*A*" and "*B*." In 1897 the snails were gathered quite closely, and in 1898 they were far less abundant; indeed, considerable difficulty was realized in completing the series.

In this connection an interesting fact has been communicated to me by Major Morrison. In sending out snails for new colonies, a number of half-grown *bandless* specimens were sent to Blairstown, Pa. This is the only colony which has been heard from and shows a preponderance of *banded* varieties.

This colony gives an interesting example of the results of a tendency to variation in a favorable environment. As far as I have been able to learn, the helix has no enemies. A few broken shells in a hen yard showed that chickens are acquiring a method of getting the animal from the shell. From my experience in collecting the snails, I should not be able to deny a certain apparent tendency to mimicry, if it were asserted; but I should hardly dare assert it. In one locality, quite protected from the light, there seemed to be a preponderance of darker shells and fused bands; among the honeysuckle undergrowth full-banded varieties were more abundant and not easy to see; in more than one locality among yellow leaves, the yellow bandless variety, or 00300, was common. It may have been imagination, but the idea of mimicry suggested itself.

In conclusion, I must acknowledge my indebtedness to Professor Cockerell for all of value there may be in this paper, but exonerate him from all responsibility for its shortcomings.

To this paper is appended a list of all the varieties known in the Lexington colony. Those specimens which have not been previously described in this colony are marked with * and among these, those of which more than one specimen has been found also with †.

Washington and Lee University,
Lexington, Va., August 25, 1898.

TABLE V. — VARIETIES OF H. NEMORALIS KNOWN IN THE LEXINGTON COLONY.

VAR. OLIVACEAE, GASSIES.
(Olive ground).

*†00300
* 00000

VAR. AURANTIA, CKLL.
(Orange ground.)

*†00000

VAR. HEPATICA, CKLL.
(Liver-colored ground.)

* 00000

VAR. ALBESCENS, MOQ.
(Whitish ground.)

*†00300
*†00000

VAR. PURPUREOTINCTA, CKLL.
(Very pale purplish ground.)

* 1(23)(45)
*†123(45)
* 00300
* $123_x(45)$

VAR. RUBELLA.
(Pink ground.)

12315
*†123(45)
*†(12)3(45)
* (123)(45)
*†$_{1}2345$
* 10345
*†$1_{2}345$
*†12045
* 120(45)
*†$12_{3}45$
* $12(_{3}3)45$
* $123_{3}45$
*^ $123_{4}45$

* $_{12}345$
10045
00300
0030_{5}
*†$003_{4}0$
* $003_{44}0$
* 003_{45}
* $_{1}0300$
* $_{12}300$
00000
* $00(3_{3})00$
* $(1_{x}2)(_{3}3)(45)$
* $(12)_{x}3(45)$
* 123 X 45
* 123 X (45)
* $123_{x}45$
* $(12)3_{x}(45)$
* $12_{3}3_{xx}45$
* $12_{3x}(4_{4})(5_{5})$
*†$003_{x}00$
003 X 00
* $003_{x}0_{55}$
* $_{122}3_{xx44}0$
* 12345_{x}
* $12_{x}3_{x}45$
* $(12)_{x}3_{x}(45)$
* $12_{x}34_{x}5$

VAR. PETIVERIA.
(Faun ground.)

12345
*†(12)345
123(45)
*†(12)3(45)
*†1(23)(45)
* ((12)3)(45)
* (12)(345)
* [12345]
* [1(23) (45)]
* $_{1}2345$
* $_{1}23(45)$
* 10345
$1_{2}345$

* 1(22)345
* 1(22)3(45)
12045
* 120(45)
* (12)0(45)
$12_{3}45$
$1(23)_{3}(45)$
123445
* $_{1}0345$
$_{12}345$
* $10_{3}45$
* $_{1}2_{2}045$
00305
*†00300
*†$12_{x}345$
* $12_{x}3(45)$
* $(12)_{x}3(45)$
* $123_{x}45$
* $(12)3_{x}(45)$
* $(123)_{x}(45)$
* $1((23)_{x}(45))$
* $123_{xx}45$
* $(1(22)3_{xx})(45)$
* $1034_{x}5$
* $(12)_{x}3_{x}(45)$

VAR. LIBELLULA.
(Yellow ground.)

12345
(12)345
1(23)45
12(34)5
123(45)
(12)3(45)
1(23)(45)

* (123)45
(123)(45)
*†((12)3)(45)
12(345)
*†12(3(45))
*†(12)(3(45))

*†1(2345)
*†1((23)(45))

[12345]
*†[123(45)]
*†[(12)3(45)]
*†[1(23)(45)]
*†[(123)(45)]
*†[((12)3)(45)]
* [(1(23))(45)]
*†[12(3(45))]

02345
$_{1}2345$
*†$_{1}23(45)$
* $(_{1}23)45$
*†$(_{1}23)(45)$
* ((11)2)3(45)
[$_{1}2345$]

10345
*†103(45)
$1_{2}345$
$1_{2}3(45)$
* $(1_{2})3(45)$
* $1_{22}3(45)$
* $1(_{22}3)(45)$
* $1_{2}2345$
*†$12_{2}345$
$1(2_{2})345$
$12_{2}3(45)$
* $1(2_{2})3(45)$
* $(12_{2})3(45)$
* $[(12_{2})3(45)]$
1(22)345
1(22)3(45)
* [1223(45)]
* $(122_{2}3)(45)$

12045
* (12)045
*†120(45)
*†(12)0(45)

* Not previously described from this colony.
† More than one specimen found.

12_345
*† $12_3(45)$
*† $(12)_3(45)$
* $[12_345]$
* $[(12)_345]$
*† $(12)_{33}(45)$
*† 12_3345
* $12({}_33)45$
$12_33(45)$
* $(12)_33(45)$
* $(12_33)(45)$
123_345
*† $12(3_3)45$
*† $123_3(45)$
*† $12(3_3)(45)$
* $(12)3_3(45)$
*† $(12)(3_3)(45)$
* $(123_3)(45)$
* $[123_3(45)]$
* $[12(3_3)(45)]$
* $[(12)3_3(45)]$
* 123345
12(33)45
1233(45)
* 12(33)(45)
* 1(233(45))
* [(1(233))(45)]
$[12_{333}45]$
* $(12)_33_3(45)$
* $[12({}_33_3)(45)]$
1233_345
$(12)_33(33)3(45)$

* 12305
* $123_{44}5$
123_445
$123({}_44)5$
1234_45
$123(4_4)5$
123(44)5
* 123(445)
$123({}_{44}4)5$
* $123({}_44_4)5$
1234445
$123_4(4445)$

*† $1234({}_55)$
* $123(45_5)$
1234(55)

* 123(455)
*† 123(4(55))

00345
003(45)
* 0_2345
* $0_23(45)$
$0_{22}345$
${}_10345$
* ${}_103(45)$
${}_{12}345$
* $({}_{12})345$
*† ${}_{12}3(45)$
*† $(1_1)0345$
* $1_103(45)$
* (11)0345
* ${}_1(2_2)3(45)$

*† ${}_12045$
*† ${}_12_345$
${}_123_345$
* ${}_123_3(45)$
* $[{}_123_3(45)]$

* ${}_123(4_5)$
${}_1234(5_5)$

10045
10_345
1_2045
$1_{23}45$
* $1_{223}45$
* 103_345
* 1_23_345
* 12_2045
* $1(2_2)0(45)$
* $(12_2)0(45)$
$[12_{233}45]$
* 122045
1(22)045

*† 103_445
103(44)5
1_23_445
* $1_23({}_44)5$
* 12_305
$12_{33}(4445)$
$12_33({}_{44}4)5$
* $123_{34}(45)$

* 12(33)(455)

123_4555
1234455

${}_10045$
${}_10_345$
*† ${}_{12}045$
*† ${}_{123}45$
${}_1(22)045$
* ${}_{112}0(45)$
* $(11_2233)45$

*† 00305
* 003_45
* ${}_{122}34_45$
* 003(445)

* 0034_5
* ${}_{12}34(55)$

* 02300

$(12)_23_{34}45$

$12_23_34(55)$

* 10300

*† 00005

00300
*† 0030_5
* 0030_{55}
003055
*† 003_40
* $003_{444}0$
* 003_{45}
${}_10300$

00000
* 0000_5
* 000_40
* 00_300
* 00_30_5
* 00_30_{55}
* $00_{34}0$
* $0_{23}0_5$
*† 00(33)00

* $00(33)_40$
$[{}_112_23_{34}4_4555]$

* $({}_x1)23(45)$
* ${}_x12045$
* ${}_x12(3_3)45$

* $1_{xxx}345$

12 X 345
(12) X 3(45)
12_x345
$12_x3(45)$
*† $(12)_x3(45)$
* $1(2^{(}{}_{x)}3)(45)$
* $1(2_x3)45$
* $(12_x)3(45)$
* $(12_x3)45$
*† $(12_x3)(45)$
* $1(2_x3(45))$
$12_{xx}345$
* $12_{xx}3(45)$
*† $1_{2x}345$
* $12_x(3_3)(45)$
* 12_x3_445
* $12_x3({}_44)5$
* 10_x3445
* $1_{2x3}3_{34}(45)$
$({}_12_{xx}3_3)(45)$

123 X 45
123 X (45)
* 123 X $_x45$
*† 120 X 45
*† 123_x45
*† $(12)3_x45$
$123_x(45)$
*† $(12)3_x(45)$
* $12(3_x)(45)$
* $(12)(3_x)(45)$
*† $(123)_x(45)$
* $((12)3)_x(45)$
* $123({}_x(45))$
* $(12)3({}_x45)$
* $(12)3({}_x(45))$
*† $(123_x)(45)$
* $((12)3_x)(45)$
*† $12(3_x(45))$
*† $1(23_x(45))$

*† $[123x45]$
*† $[123x(45)]$
*† $[(12)3x(45)]$
* $[(12)(3x)(45)]$
* $[(12)(3x45)]$
$123_{xx}(45)$
* $(12)3_{xx}(45)$

*† $_{1}23x45$
*† $_{1}23x(45)$
* $[_{1}23x(45)]$
*† $1_{2}3x45$
$1_{2}3x(45)$
* 120×45
* $120_{x}(45)$
$120_{xx}45$
*† $12_{3x}(45)$
$12_{3xx}45$
$12_{3xx}(45)$
$12(_{3}3)_{x}(45)$

* $(12)(_{3}3)_{x} \times (45)$
$1(23_{3})_{x}(45)$
* $(12)(33)_{x}(45)$
* $((12)(33))_{x}(45)$
* $12_{3}3_{3x}45$
* $123(x445)$
* $123x4(55)$

* $_{1}03x45$
* $_{12}3x45$
* $1_{122}3_{xx}45$
* $_{1}20_{x}(45)$
* $1_{22}3_{xx4}45$
$12_{3x4}45$
$1_{2}3x4_{4}(55)$
* $12_{3x}(4_{4})(5_{5})$
* $003_{x}00$
$00(3_{x})00$
* $0033_{x4}0$
$000_{xxx}00$

* $1234x5$
* $1034(x5)$
*† $1_{2}34x5$
* $1_{22}34x5$
* $12_{2}34x5$
* $1230_{x}5$
* $123_{4}4x5$
* $_{1}034x5$
$1030_{x}(_{5}5)$

$1_{x}03x45$
* $1_{x2}3 \times 4(_{5}5)$
* $[(1_{x}2)(_{33}3)_{xx}(45)]$

* $12_{x}3x45$
* $12_{x}3x(45)$
*† $(12)_{x}3x(45)$
* $(12)(x3)_{x}(45)$
* $12_{x}3(x(45))$

* $(12)(x3x(45))$
* $1(2_{x}3x(45))$
* $[12_{x}3x(45)]$
$12_{x}3_{xx}45$
* $12_{x}3_{xx}(45)$
* $[(12)_{x}3_{xx}(45)]$
$12_{xx}3_{xx}45$
* $12_{x3x}(45)$
* $(12)_{x}(_{3x}(45))$
* $12_{x}(33)x45$
* $12_{x}(33)_{x} \times 45$
$1_{2x}3(\times 4)5_{5}$
* $((12)_{x3}3)_{xx}(4(55))$

* $1_{22}(_{3}3)_{x}(4x5)$
* $123(x) \times 4(x5)$

* $1_{x2xx}3x4_{4}5$

Total varieties enumerated, 385. New varieties enumerated, 277.

New varieties found in more than one specimen, 77.

THE WORK OF THE CONCILIUM BIBLIOGRAPHICUM.

HERBERT HAVILAND FIELD.

SINCE the foundation of the Concilium Bibliographicum in January, 1896, no notices concerning its work have been sent to the scientific journals, although statements have occasionally been solicited. The reason for this reticence has been the fact that its work has heretofore been rather of the nature of a vast and expensive experiment than of a publication which could stand before the world as an agency able to render fully the services for which it was called into existence.

In this first or experimental stage all have had to bear a share of the burden, and we have reason to be grateful for the patience which our subscribers have shown under these trying circumstances. Liberal as were the donations to the work, they none the less proved insufficient, and the director of the institute has not merely been obliged to work or rather to overwork for three years without a salary, but has been forced to submit to serious financial loss. At present this has been changed, and although the work cannot become remunerative, yet it may now be regarded as definitely assured, thanks to the permanent subsidy voted to it by the Confederation, the Canton, and the Town. It has been placed under the supervision of a joint commission containing representatives of these several interests.

It must not be supposed from this statement that the Concilium is no longer behindhand in its work. Such a change cannot be accomplished in a few days nor in a few weeks. As a fact, however, more cards are now being issued than would correspond to the actual rate of zoological publication, so that we can see our accumulated manuscript growing daily less. When this shall have been entirely disposed of, we shall be able to obtain the proper benefit from the present arrangement of the work.

In the house with the main offices is a specially equipped composing room, where at present three typesetters and a head typographer give their entire time to the Bureau. In a neighboring building the large cylinder press has been set up, as well as a paper-cutting machine in charge of a special machinist. With this staff of employees, we are able to print and issue nearly 100 different cards a day. For sorting the cards a double check system is used, which makes errors almost impossible.

In regard to classing the cards, we were at first inclined to consider this of secondary importance, the arrangement being the concern of the user. We have found, however, that such a course would be simply disastrous. The entire bibliography is a structure growing by internal additions, as an animal or a plant does. Consequently, every element must have a definite destination. For a catalogue of current literature in pamphlet form such a chapter heading as Fauna of the Celebees would be far too detailed; not so for a great catalogue destined to receive the contributions of many years. Indeed, we go much further and arrange the papers on the Celebees according to the animals dealt with. Thus there is a place reserved for the Lizards of Celebees; possibly there are already cards at that place, possibly some will be added in the coming year.

It is obvious that our central catalogue can be arranged with such detail; but how can we duplicate such a catalogue in the hands of our subscribers? With such an overwhelming number of divisions, how can one find Celebees? In a book one can have an index with references to the pages; can one not apply a similar system to cards by numbering the places in which cards may be entered? It is evident that such a course is perfectly practicable, and it is this that we have done with the single modification that we have preferred to choose such numbers as would permit us to enlarge our scheme at will. It is needless to explain how this last requisite has been reached. In the past such explanations have been given and have only served to render complicated a very simple matter. It is not at all necessary to understand how logarithms are calculated to use a table for a definite mathematical problem, and so it is with our numbers.

If one is desirous of knowing what has been published in regard to Faunæ, one has only to look in the index to see that they are dealt with in section No. 19. If one is interested in the Celebees one can find them at division 19 (912). People talk of these numbers as if we expected them to be learned by heart, or as if they were intended to convey information by a sort of symbolism. They are not one iota more complicated than the page references in any book index, after one has learned that the numbers are read successively from left to right, so that all numbers beginning with 1 (19, for instance) come before 2, etc. Personally I see no reason for regarding section No. 78, in which we have Anura, as in any sense more complicated as a number than section 435, where they stand in Leunis. Neither does it seem to me too mathematical even for zoologists having an "aversion to numbers." The system is a purely practical device and is not affected by idle talk about the theoretical unsoundness of classifying by groups of tens. Equally irrelevant is the remark that our classification is not scientific. We know it is not, and we often regret that it is not less scientific. I am well aware that the system we use follows the scientific separation of Reptiles from Batrachians ; bibliographically, this is of doubtful advantage, and the practical bibliographer often wishes he had some common ground where he could place Herpetology, before entering in upon works dealing with each group by itself. Not until people cease being specialists in regard to both Amphibians and Reptiles will the need for a common division also disappear.

For purposes of subscription almost any conceivable topic will be received, no matter how restricted it may be, the price varying from one-fifth of a cent to one cent a card, according to the size of the order. Innumerable sets cost from ten to twenty cents. Such prices have been fixed in order to establish relations, if possible, with the whole body of zoologists. It seems as if under such conditions 500 subscribers ought to be possible in the United States alone.

The complete series are designed rather for libraries, museums, and laboratories. In our opinion every scientific center should have at least one such set. In the United States, how-

ever, this is far from being the case. Thus, in New England, Williams College has the only such set. On the Atlantic seaboard such orders have been further received from Columbia, Cornell, Pennsylvania, and Princeton. Minnesota has two such ; Iowa and Illinois each one. The more restricted set, in which each paper figures but once, usually in the systematic part, has a far wider circulation. Nine sets go to Massachusetts, one to Rhode Island, a number to the Washington departments, two to Ohio, and one each to Indiana, Michigan, Wisconsin, Minnesota, Iowa, and Kansas. As will be seen from this summary, there are still districts where no complete set can be seen. This is a pity, since we are rapidly nearing the time when no more back sets will be available.[1]

In regard to the anatomical and physiological bibliographies, it may be said that they too are nearly ready to be pushed, as is now being done for the zoological portion. A delay took place in consequence of a rupture with our former printer, so that in order to issue the book edition of the *Bibliographia Physiologica* we were obliged to set the entire work a second time. This has been done and we can now return to the cards.

In order to facilitate relations with the United States, Mr. Edward S. Field, of 80 Leonard Street, New York, has been authorized to receive subscriptions. A large number of descriptive circulars will be deposited in his office and may be had on application.

[1] South America has given us many complete orders, as also Hawaii.

ON PROTOSTEGA, THE SYSTEMATIC POSITION OF DERMOCHELYS, AND THE MORPHOGENY OF THE CHELONIAN CARAPACE AND PLASTRON.

O. P. HAY.

THE structure and relationships of the genus of fossil turtles known as Protostega are being gradually determined. Important additions to our knowledge regarding it have been made recently by Dr. E. C. Case[1] and Mr. G. R. Wieland.[2] The former describes and figures in an excellent way the plastron, the skull, the shoulder girdle, and the limbs; and discusses at length the relationships to the other Testudines. Mr. Wieland supplies needed information regarding the ribs and the existence of neuralia. He regards the form which he describes as a new genus, which he calls Archelon, but it will be generally agreed, I think, that it is not distinct from Protostega.

One of the most important discoveries made by Case is the arrangement of the xiphiplastrals. When I wrote my paper[3] on the portion of the plastron of this animal then in my hands, I assumed that the xiphiplastrals had essentially the same form and dimensions as in the modern genus Thalassochelys. Case finds that, on the contrary, immediately after these plastral elements have freed themselves from the hypoplastrals they sharply curve toward the mid-line and come into contact. The length of the plastron is thus much reduced. Dr. Case also concludes that the epiplastrals must have been much shorter than they are in Thalassochelys, and that the entoplastron was probably wanting. From this condition of the plastron Case concludes that my estimate of the size of Protostega was much

[1] *Journ. of Morphology*, vol. xiv, pp. 21–55, Pls. IV–VI.

[2] *Amer. Journ. Science* [4], vol. ii, pp. 399–412, Pl. VI, and 19 text-figures.

[3] *Field Columbian Museum Pubs.*, *Zoology*, vol. i, pp. 57–62, Pls. IV, V.

too great, his own calculation making the total length 2.273 meters, as against my own estimate of 3.92 meters — a very considerable difference.

However, I do not believe that Case's conclusion necessarily follows from his premises. My estimate was primarily based on the distance from the bottom of the excavation in the hypoplastron for the fore limb to the excavation in the hypoplastron for the hind limb. It seems to me highly probable that these borders of the plastron could not have approached the corresponding limbs of Protostega more closely than they do in Thalassochelys and yet leave the limbs free to make their movements. The limbs, then, must have been as far apart as they would be in a Thalassochelys whose plastron had the corresponding measure equal. Hence any shortening of the body must have been effected in front of the fore limb and behind the posterior limbs. This would necessitate the shortening of the anterior dorsal and the anterior caudal vertebræ; and of this we have no proof. The dimensions of the various plastral elements are extremely variable in the various genera of turtles; and it hardly follows that, because the xiphiplastrals are very short, the body of the animal is correspondingly curtailed. The estimate of the length made by Wieland, based on his apparently quite perfect carapace, is not greatly less than my own estimate.

I wish here to make a remark on the genus Atlantochelys of Agassiz. It has been thought that it is identical with Protostega of Cope; but a comparison of Leidy's figure[1] of the humerus, on which the name was based with that of Protostega, shows that the two genera are very distinct. The humerus of Atlantochelys contracts below the tuberosities into a much more slender shaft than does Protostega. The humerus of *Atlantochelys mortoni* resembles not distantly that of Lytoloma, as figured by Dollo.[2]

It was the judgment of Baur,[3] also, that Atlantochelys is different from Protostega. Cope's *P. neptunia* is merely a

[1] *Cretaceous Reptiles, U. S.*, Pl. VIII, Figs. 3–5.
[2] *Geol. Mag.* [3], vol. v, p. 266.
[3] *Biolog. Centralblatt*, Bd. ix, p. 189.

synonym of ***Atlantochelys mortoni***, the latter name dating from time of Leidy's figure and description, 1865.

In his discussion of the relationships of Protostega to the other Testudines, Case succeeds completely, in my estimation, in proving that the genus under consideration belongs near the Cheloniidæ. Many authors have assigned to it definitely a position among the Dermochelyidæ; but this disposition of it was doubtless due to Cope's error in regarding the plastral plates as portions of the carapace.

Case also endeavors to prove that Protostega is not distantly related to Dermochelys; that it is, in fact, "a distinctly intermediate form" between Dermochelys and the Cheloniidæ. Dermochelys is, therefore, not worthy of being made the foundation of a distinct suborder, the Athecæ of Cope, but is a member of the superfamily Chelonioidea.

As anatomists are aware, the late Dr. Baur strenuously opposed the proposal to remove Dermochelys far from the company of the other sea turtles. Like Dr. Case, he regarded it as having been derived from the Cheloniidæ, differing from the others in having become more highly specialized for aquatic life.

Baur's arguments had evident effect on his antagonists; and it will doubtless be admitted by all that he and Case have valiantly defended their position. Now that Protostega has been definitely shown to belong near the Cheloniidæ, many will, no doubt, be inclined to believe that the defended position is unassailable. Notwithstanding all this, I have not been able to divest myself of the feeling that Dermochelys is not to be admitted into the same suborder as the other living sea turtles. And here I recall the words of Van Bemmelen, who felt strongly the force of the arguments employed by the opponents of Baur, but found himself compelled to accept the views of the latter.

As regards Protostega, it appears to me that Case's investigations show conclusively that it has no special relationships to Dermochelys. It is in no important sense an intermediate form; and Case has not so regarded it in his scheme showing lines of descent.

I shall not enter into any extended discussion of those structures which Dermochelys possesses in common with the other sea turtles. Most of them have already received consideration from Baur, Dollo, Boulenger, Van Bemmelen, and Case. Some of these common characters may be attributed to inheritance from a common remote ancestor; such are, for illustration, the wide separation of the pterygoids seen in both Protostega and Dermochelys, and the roofed-in condition of the temporal region found in Dermochelys and the Cheloniidæ. Other characters possessed in common may be due to convergence, resulting from similarity of habits, movements, etc. I would include in this category the presence of an articulation between the eighth cervical and the nuchal, the plane surfaces of articulation between the sixth and seventh cervicals, and the more or less reduced condition of the carapace and plastron. Probably the surfaces joining the sixth and seventh cervicals are plane for the same reason that they are plane between the various dorsal vertebræ ; namely, this articulation is one situated where there is only slight movement, lying, as it does, between two curves in opposite directions.

But whatever may be the conclusions reached concerning the other points in the anatomy of Dermochelys, its singular dorsal and ventral shields form one of the most striking characters of the animal, the one about which there has been the most contention, and the one which probably furnishes the key to the situation. The condition and mode of origin of this carapace were the most difficult matters for Baur to explain ; and regarding its morphogeny he changed his mind more than once. At the time the discussion was going on between himself and Dollo and Boulenger, Baur took the position that the carapace of Dermochelys had been derived from that of its Chelonioid ancestors through delamination of the layer of membrane bone from the ribs, and the dissolution of this into polygonal pieces. Later he came to the conclusion that the membrane bone of the carapace of Dermochelys had become wholly, or nearly wholly, reduced, and that the layer of mosaic-like pieces was of secondary origin, an entirely new development. Case adopts this later expressed opinion.

This view, however, is not without difficulties of its own. Dollo and Seeley have both referred to the fact that the dermal plastron of Dermochelys is not complete; that is, the bony mosaic is deficient in the spaces between the longitudinal keels of the plastron. Shall we now regard this condition as a stage on the way toward a complete plastron; or shall we hold that the complete plastron was once possessed and that the present condition was due to reduction? The former way of looking at the matter is opposed to the fact that Dollo and Seeley concluded that Psephophorus, a close ally of Dermochelys, living in the Miocene, possessed a continuous plastron of mosaic-like pieces. If the latter view is held, we might properly inquire how it happens that nature is so vacillating regarding the needs of this animal.

We may well doubt, too, that there has been sufficient time granted the Dermochelyidæ in which to effect the change in their armor. Case derives the family from Lytoloma, of the upper Cretaceous and lower Eocene; but both Eosphargis and Psephophorus had appeared already in the Eocene. This implies rapid modifications of structure. On the other hand, it is evident that changes go on in the turtles very slowly. How much progress in the reduction of the carapace and plastron, for instance, has been effected in the Cheloniidæ since Cretaceous times?

A difficulty affecting not only Baur's later view, but also the earlier one, is experienced in endeavoring to understand what advantage Dermochelys has gained over the alleged old-fashioned turtles by undergoing its various supposed adaptive changes. The thecophore sea turtles are more numerous in genera, species, and individuals than the Athecæ, notwithstanding the fact that the former have been relentlessly pursued for their flesh, their shell, and their eggs. As an ancient, intractable form, with difficulty adapting itself to its environment, we can understand Dermochelys.

Seeley[1] has felt the necessity of accounting for the origin of the armor of turtles in a way different from that usually adopted. He thought that a portion of the carapace had its

[1] *Quar. Journ. Geol. Soc.*, vol. xxxvi, p. 410. London, 1880.

origin in bone developed, not in, but beneath the skin ; and he suggested that the uncinate processes of the ribs of the crocodiles and birds might afford a clue to the solution of the problem. However, these uncinate processes are of cartilaginous origin, while the bony plates which constitute the greater portion of the carapace are of membranous origin.

We must recognize, at least in the Amniota, besides the bones developed from a basis of cartilage, two kinds of membrane bone. One of these is developed within the external integument itself ; the other in the fasciæ, beneath the skin. Examples of the first kind, or true dermal bones, may be found in the osteodermal plates which occur in the scales of the Scincidæ and of some other lizards. Such, too, are the pieces which form the mosaic armor of Dermochelys. Examples of the second kind of bones, or fascia bones, are furnished by the so-called abdominal ribs of Sphenodon. Of course the two kinds may often coalesce with each other or with cartilage bones.

In the abdomen of the cayman both strata of bones occur. There is a set of abdominal ribs developed in the subcutaneous fascia, while in the skin itself there is a system of bony scutes which constitute a ventral armor. Sphenodon likewise possesses a system of abdominal ribs, which are wholly independent of the true ribs ; but there is no dermal armor. If bony plates were developed in the ventral scales of Sphenodon, we would find two strata of bones, as in the cayman.

The abdominal ribs of Sphenodon, then, are homologous with those of the cayman, and not with the latter's dermal armor. It is generally agreed that most of the plastral bones of the turtles find their equivalents in the abdominal ribs of Sphenodon, not in the dermal armor of the cayman. The epiplastra and the entoplastron of the Testudines are doubtless the homologues of the clavicle and the interclavicle of other reptiles and of the Stegocephali, and belong to the same stratum of bone as the abdominal ribs.

Now it seems to me almost certain that the marginal bones of turtles have had the same origin as the bones of the plastron; that is, they are not dermal bones, but fascia bones. Further-

more, I see no reason why we may not regard the nuchal bone and those plates of bone which have united with the neural spines to form the neuralia, and with the ribs to form the costalia, as having originated in the same way. Two strata of bones might as reasonably be expected to occur on the dorsal region of the body as on the ventral. In accounting for the condition of the carapaces of modern turtles, we may suppose that the earliest ancestors of turtles had a scaly skin, which contained osteodermal plates.[1] Beneath these there were developed first, perhaps, in the fascia of the shoulders, a nuchal bone, later other plates which in time became transformed into the neuralia and costalia. As these deeper-seated fascia bones increased in importance, the osteodermal plates underwent gradual reduction. Only in Dermochelys have they maintained anything like their early importance. As regards the deeper layer of bones even in this turtle, the ribs, flattened, and with jagged edges, seem to me to indicate that at some time in the remote past there have been costal plates of membrane bone fused with them.

Can we find any evidences bearing on the hypothesis proposed?

In Vol. iv of the *University Geological Survey of Kansas*, pp. 370 *et seq.*, Case has described and given figures of three species of the genus Toxochelys, not uncommon turtles of the upper Cretaceous deposits of Kansas. While working in Dr. Baur's laboratory in the University of Chicago, I had the privilege of studying and of making drawings of the specimen of *T. serrifer*, which Case has presented on his Pl. LXXXIII. This specimen is the property of the paleontological department of the University of Kansas, now in charge of Dr. S. W. Williston. One of the most interesting observations that resulted, one that has often been recalled to mind, was that there

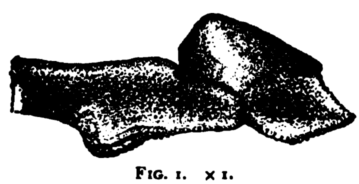

FIG. 1. × 1.

was evidently a series of separate bones along the middle of the back, lying across certain of the articulations between neurals.

[1] Baur, G. *Biol. Centralblatt*, Bd. ix, p. 182; *Sci.*, vol. xi, p. 144.

Case has figured one of them and referred to it in his description on page 382. He has, however, scarcely done it justice when he refers to it as a thin ossicle. Fig. 1, here presented, gives a lateral view of this ossicle and of the seventh and eighth neuralia on which it rests. The figure is of the size of the object.

The drawing that I made of the carapace, seen from above, is slightly different from that of Dr. Case, and I here reproduce such part of it as pertains to the bones involved (Fig. 2), one-half natural size. It is my opinion that Case has made the fifth and sixth neuralia exchange places in his drawing. My reasons for so thinking are these : On the anterior end of neural 7 of Case's figure (9, according to his notation) there is an excavation that is not filled up as he has placed the bones ; while as I have placed them, this excavation is accurately filled by a process from my neural 6. Again, Toxochelys evidently had, like its relatives, Thalassochelys and Chelydra, a system of epidermal scutes. Now, in these last-named genera, and in the great majority of other turtles, the suture impressions of these scutes cross the first, third, fifth, and eighth neuralia. The exceptions are rare. According to Owens's[1] figure, the suture between the fourth and fifth scute passes across behind the eighth neural. Now, as I have arranged the neuralia, the dermal sutures are in their proper places. Another suture would probably cross just behind the ossicle lying across the suture, between neuralia 7 and 8.

FIG. 2. × ½.

At the anterior end of neural 5 there is an excavation which had evidently served for the reception of an ossicle like the one across neurals 7 and 8 ; and in the collection there was then a bone like the ossicle referred to, and it quite accurately fitted the excavated surface. At that time there was no doubt that those bones belonged as they were drawn. There was also in the collection another bone, which I have figured as the

[1] Owen. *Anat. Vert.*, vol. i, p. 61.

third neural. It has, as it should have, an epidermal sutural impression across it. On the anterior end of this bone there was present a prominent tubercle, which in form and position resembled the distinct ossicles further behind; but there was no suture at its base. The conclusion drawn was that it was once distinct but had become coössified with the underlying neural.

Fig. 3 represents, of actual size, another bone that was found in the same collection of Toxochelys materials. Its upper portion resembled closely one of the ossicles described above; but below this there was a thinner portion, which had evidently been buried in the flesh. It was regarded as equivalent to one of the rows of bones which are to be found along the upper edge of the tail of Chelydra.

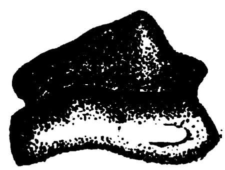

FIG. 3. × 1.

It seems to me evident, therefore, that that row of tubercular ossicles along the back of Toxochelys was simply a continuation forward of the row that, like those of Chelydra, must have been present on the tail. These last must be reckoned as of purely dermal origin; so, too, must those on the carapace. Moreover, the neuralia on which they were reposing must belong to a deeper stratum of bone.

A median keel along the back is a not uncommon feature of turtles. Nearly all species possess it at an early stage of life; although it may become obsolete as growth proceeds. In some tortoises this keel is elevated at intervals into prominent tubercles. These occur near the hinder border of each of the median bony scutes. *And that is just where those tubercle-like ossicles of Toxochelys were found.* I conclude, therefore, that these dorsal tubercles of our existing turtles have originated from a median dorsal row of dermal bones, distinct in the earlier forms, but now ossifying continuously with the underlying neurals. In the young of the diamond-back terrapin (*Malaclemys terrapin*) these dorsal tubercles are greatly developed and consist of four or five globular masses like small peas. It would be interesting to have their development studied, in order to ascertain if possibly they may yet possess distinct centres of ossification.

If we examine the carapace of a specimen of Dermochelys, or, in lieu thereof, the plates presented by Gervais,[1] we shall find that along the mid-line of the dorsal surface there is a row of enlarged bony plates, each bearing on its upper surface a prominent ridge. If we suppose that the early ancestors of our common turtles had at once a carapace like that of Dermochelys and a more or less rudimentary carapace of the common kind, it will be easy to comprehend that, as the dermal carapace underwent reduction, some of the larger median plates remained behind, first as independent ossicles, then as mere knobs on the neuralia.

A further examination of the test of Dermochelys proves that on the upper surface there are six more keels, three on each side. The third keel on each side, reckoning from the mid-line, forms the margin of the carapace; the two others are between it and the median keel. Each of these ridges, or keels, is composed of polygonal bony plates considerably larger than those occupying the spaces between the keels.

In a considerable number of species of turtles there are to be found on the carapace three keels, a median and two lateral. The lateral keels, although usually not so prominent as the median keel, are sometimes quite as well developed, and are occasionally conspicuously tuberculated. The median and the lateral keels are to be seen in young individuals of the snapper (Chelydra), and are strikingly displayed in large specimens of the alligator snapper (Macroclemys). In the latter species the tubercles are very large and projecting. Other tricarinate species are *Staurotypus triporcatus*,[2] *Damonia reevesii*,[3] and *Nicoria trijuga*.[4] These lateral keels occupy exactly the position held by the first pair of lateral keels of the carapace of Dermochelys; and it seems to me entirely probable that they have been inherited from a common ancestor, and have been produced from rows of distinct ossicles, as the middle keel has.

A search among various genera of thecophore turtles for traces of the second pair of lateral keels, as seen in Dermo-

[1] *Nouv. Archives du Museum*, vol. viii (1872), Pl. IX.
[2] Gray. *Catalogue Shield Reptiles*, pt. i, Pl. XX B.
[3] *Op. cit.*, Pl. V. [4] *Op. cit.*, Pl. IV.

chelys, was less fruitful; and I had about concluded that all vestiges of them had vanished. Finally, however, I was led to examine more closely the carapace of Macroclemys. These turtles alone among all living forms, so far as I know, possess a row of three or four epidermal scutes lying along each side between the costal scutes and the marginals. They are known as supramarginals. Each of these areas is lifted up into a rounded knob somewhat like the tubercles of the keels higher up. This row of knobs I regard as the last remaining vestiges in the Thecophora, of the second pair of keels of the ancestral turtle. This pair of keels in Dermochelys may properly be called the supramarginal keels.

As to the third pair of lateral keels, they have probably left traces of themselves in the serrations that mark the margins of the carapace of many turtles, more especially the posterior margins.

The ventral surface of Dermochelys is provided with five keels, two lateral on each side and a median. The two lateral pairs are most conspicuously developed in a young Dermochelys recently hatched. These keels, both dorsal and ventral, may be of some use in swimming, in maintaining the body in a direct course; but the adults of other sea turtles are without more than the merest traces of them. Nevertheless, some of the ventral keels are well developed in the young of the marine turtles. In a young Thalassochelys[1] the first pair of lateral keels runs along the middle of the hyo- and hypoplastral bones, and these keels are conspicuously tuberculated. In the same individual the keels of the second pair are seen to run along the rows of inframarginals and are also tuberculated. Relatively few turtles possess inframarginals, and it was the finding of the lateral keels in Thalassochelys that suggested to me an examination of the supramarginals of Macroclemys in my search for traces of the corresponding keels on the upper surface of the body.

The plastron of Toxochelys possesses on each side a low but sharply defined keel, which corresponds to one of the first pair of Dermochelys. It is represented in Case's figure. We should

[1] Agassiz, A. *Cont. Nat. Hist., N. A.*, vol. ii, Pl. V, Figs. 14–16.

hardly expect a huge sea turtle like Protostega to possess a pair of plastral keels; but that such were present may be seen from the examination of my figures of this plastron.[1] A few turtles which are fitted for existence on the land also have these keels. They may be seen in Gray's figures of *Kachuga lineata* and *K. dhongoka*.[2] I find no tubercles that furnish evidences of remains of the median ventral keel in any turtles except Dermochelys. This keel appears to have quite completely vanished. I shall, however, return to a consideration of it. All the keels, as we now find them in the Thecophora, I look upon as having originated through the fusion of rows of distinct dermal ossicles with the underlying bones of the carapace and plastron.

The presence, in turtles of so many and so widely removed families, of these keels and rudiments thereof, always more or less tuberculated at an early stage of life, is rendered comprehensible if we once admit that the common ancestors of the groups possessed corresponding rows of tuberculated bones. On the other hand, the possession of these numerous keels by Dermochelys is, we might say, incomprehensible if we are to suppose that it took its origin from a race of sea turtles that had completely, or nearly completely, lost the carapace and plastron. If the structure of the new carapace had anything to do with that of the old one, and if the keels of the superior second lateral pair were really associated with the supramarginal scutes, how could these keels have reappeared in Dermochelys if this were derived from a stock which had no supramarginals or supramarginal keels? If the disposition of the new carapace had nothing to do with that of the old, how came it that we can seem to find such close correspondences? Dermochelys would offer a most remarkable case of convergence or reversion.

One of the most remarkable facts about turtles is the want of correspondence between the horny scutes of the carapace and plastron and the bones which underlie them. When osteodermal plates are developed in the crocodiles and lizards, they are overlain by corresponding horny scutes. In tortoises, on the contrary, each lateral horny scute of the carapace covers a

[1] *Field Columbian Museum Pubs., Zool.*, vol. i, Pls. IV, V.

[2] *Catalogue Shield Reptiles*, pt. i, Pls. XVII, XVIII.

costal plate, the half of the plate next in front, and the half of the plate next behind. The neural scutes are similarly disposed, covering sometimes wholes or parts of from two to four neurals. The marginal scutes are only as long as the marginal bones which they cover; but, instead of coinciding with the latter, they "break joints" with them. Neither do the plastral scutes coincide with the bones of the plastron. It is evident that the scutes have had a development wholly independent of the bones beneath them. How has this occurred?

The skin of the adult Dermochelys is wholly devoid of division into areas resembling scales or scutes; but in the young, a fine specimen of which I have been permitted to examine in the National Museum, the skin is everywhere, on body and limbs, broken up into small polygonal areas. Along the dorsal and ventral keels these areas are considerably larger than elsewhere. It is quite certain that these areas coincide with the osteodermal plates which are, or will be, developed in the skin. When the bony plates have increased in size, the overlying scute has become correspondingly extended.

I conclude, therefore, that the earliest turtles were covered with numerous small horny scales, possibly overlapping like those of lizards; and that in the dermis beneath these scales there were produced osteodermal plates. From such an ancestor, land-inhabiting, and having limbs fitted for such a life, there arose a race that has culminated in our leather-back turtle. This race early betook itself to an aquatic life, and its limbs suffered profound modifications. Possibly also the epidermal structures and the underlying bony plates became more or less modified. Quite certainly the deeper carapace and plastron underwent considerable reduction. The nuchal bone, however, remains to the present day.

From the same primitive ancestors that gave birth to this athecate tribe there arose another vigorous race, whose members tarried longer on land. In the members of this branch of the Testudines the elements of the more deeply developed shield were probably present, but in a somewhat rudimentary state. To such an animal, with probably a broad and inflexible body, slow of movement, and with few defenses, it would have

been advantageous to have a more resistant armor than that afforded by a layer of small articulated dermal bones. Fewer and larger bones, resting on and perhaps breaking joints with the as yet perhaps rather indifferently developed fascia bones, would have rendered the shield less vulnerable. It was only natural that the osteodermal plates of the already present keels, and indeed only a few of these plates, should grow at the expense of the smaller surrounding plates. As these few plates extended themselves at their base, they rose above the surface in the form of tubercles or spines. Possibly it was their function as spines that determined their growth. The result was finally, as I view the matter now, that one of these plates, with its correspondingly extended epidermal scute, occupied most of the space now covered by each of the scutes of our living turtles. At length the deeper elements of the carapace and plastron attained such a stage of development that the dermal bones were of small service, and they began to undergo reduction; but this reduction did not necessarily interfere with the subsequent growth of the epidermal scute. In some cases the extirpation of outlying isolated patches of horny epidermis is not yet complete, as may be seen on the plastron of Chelydra. As already suggested, not only have the keels disappeared from many turtles, but in many cases even the epidermal scutes, which became associated with the ossicles of those keels. The supramarginals have disappeared from all except Macroclemys. The Cheloniidæ possess inframarginals; so, too, does Dermatemys. *Staurotypus triporcatus*[1] has a row of only two inframarginal scutes lying across its shortened bridge. In most genera the pectoral and abdominal scutes have come into contact with the marginals. There are, then, often found at each side of the bridge a scute, the axillary and the inguinal. These are doubtless vestiges of the inframarginal keels.

That the epidermal scutes have originally taken their start from the individual tubercles of the various keels, may be seen on examination of the scutes in almost any of our turtles, more especially the lower forms, Chelydra, Malaclemys, etc. In the

[1] Gray. *Catalogue Shield Reptiles*, pt. i, Pl. XX B.

neural scutes the lines of growth show that the tubercle at the posterior border is the starting point; and from there the scute spreads mostly forward and laterally. In the costal scutes the growth begins near the upper hinder angle and spreads downward and forward. If there is a lateral keel, its tubercles form the starting point. From these the scutes have spread toward the marginals, and between the former and the latter the supramarginals have been suppressed. It might be supposed that the manner in which the epidermal scutes extend themselves is determined by the growth of the underlying bones; but a study of the relations of the two sets of structures will, I think, disprove this idea. These scutes are simply following the course laid down by their predecessors. In some of the higher turtles, as species of Testudo, the centre of growth, the areola, of some of the scutes has moved nearer the centre of the scute.

The great scutes of the plastron all grow from a point near the posterior outer angle forward and toward the mid-line where they have met. In doing this they have suppressed the scutes of the middle keel. To a less extent they have grown upward and forward, and have thereby suppressed partially or wholly the inframarginals.

If the reader will examine the figures on Pls. XXII–XXV, of Gray's *Catalogue of Shield Reptiles*, Pt. i, and Pl. VI of Boulenger's *Catalogue of Chelonians*, he will find a large scute on the mid-line of the plastron of each of the turtles there depicted, near the anterior end, and, except on Pl. XXIII, surrounded by other scutes. This is the intergular. It occupies the position where the median and first pair of lateral keels of Dermochelys come together. Indeed, it is located rather on the territory where the median keel would end anteriorly. Its lines of growth show that it spreads from a central point in all directions. This intergular has very much the appearance of having originated from the median plastral keel. Usually the intergular extends forward to the anterior margin of the plastron and is smaller, as in Gray's *Catalogue*, Pls. XXVII, XXVIII (*Podocnemis*). In such cases it less forcibly suggests an origin from the median keel, and has evidently undergone great reduction.

An inspection of the plastron of the alligator snapper (Macroclemys), or of the figures on page 26 of Boulenger's *Catalogue of Chelonians*, shows that in this genus there is sometimes present an intergular shield. This remarkable turtle, then, has vertebral, costal, supramarginal, marginal, and inframarginal shields, a row consisting of the usual plastral shields, and occasionally an intergular, that is, *rows of epidermal shields representing all twelve of the longitudinal keels of Dermochelys and, as I believe, of the ancestors of all the groups of turtles.* So far as I know, there is no other turtle which shows all these. The marine turtles are not far behind, since they present traces of all the keels, except the supramarginals.

The number of epidermal shields and of the hypothetical osteodermal plates belonging to each keel of the thecophorous turtles is, of course, much smaller than in Dermochelys, about one in each keel of the carapace for two vertebræ and pairs of ribs. An examination of the bony plates which form the armor of the sturgeon reveals some characters in common with those which we suppose once belonged to the turtles. They are broad-based, rise into a backwardly directed spine, and in number are about one-half as many as the ribs and vertebræ which underlie them. On the tail of Chelydra, a cousin of Toxochelys, the dermal bones which produce the serrations of that tail fall in number considerably below the vertebræ on which they rest.

Reflection on the early state of the Chelonian armor has led me to study the condition of corresponding structures in Sphenodon, that reptile whose position lies so close to the base of the reptilian stem.

Many reptiles, as is well known, possess longitudinal rows of enlarged scales, especially one which forms a crest along the dorsal mid-line ; and it occurred to me that possibly Sphenodon would show not only this but traces of other keels. What I find is as follows : On the dorsum of the tail there is a row of quite large horny tubercles, which resemble quite closely those seen on the tail of Chelydra. In none of them, however, do I find ossifications.[1] If any such have ever been present, they

[1] Günther, A. *Philos. Trans. Roy. Soc.*, vol. clvii (1867).

vanished long ago. Lvoff, however, states[1] that he has found minute ossifications in the teeth of the crest of Sphenodon. This row of tubercles is continued forward to the head, with one or two interruptions, by a series of thin horny plates.

On each side of the tail are evidences of two other keels. Of these, the upper appears to occupy the position of the costal keel of the turtles; the other the position of the marginal keels. On the trunk I find no satisfactory evidences of the existence of lateral keels, although there are some scattered enlarged scales. On the rump I find a rather interesting thing, although it may have no significance. On each side is a row of pointed scales, about six in number, which begins near the upper end of the ilium and runs backward and toward the median crest. These two rows of scales suggest the hinder borders of the carapace of Dermochelys.

A dissection of the tail of Sphenodon proves that there is just one horny tubercle on its dorsum for each neural spine. Between the bases of adjacent tubercles folds begin and run downward on each side across the tail; on the under side of the tail there are, between the successive folds mentioned, two transverse rows of enlarged scales. On the sides of the tail the epidermal scales are much smaller and more numerous.

On the belly the epidermal scales resemble those found on the under side of the tail. On the side of the trunk they are again very small. A careful reflection of the skin of the belly brings to light the "abdominal ribs," or gastralia, as they have been called by Baur. Immediately behind the sternum the skin is loosely attached to them; but along most of the belly it is closely adherent. There are about twenty-five of these gastralia.[2] Each may be said to resemble a very open capital V, with the apex directed forward. Each consists of three closely united bones; one forming the apex of the V and a portion of its sides, the other two forming the extremities of the sides of the V. Now, there is a cross row of epidermal scales for each of these gastralia, and two of the latter for each pair of ribs. In fact, the lower ends of the ribs are attached to alternate

[1] Lvoff, W. *Bull. Soc. Imp. Natur. Moscou*, vol. lx, pt. ii, p. 333.

[2] Günther, A., *loc. cit.*

gastralia. In crocodiles the gastralia are only equal in number to the pairs of ribs in the same region of the body. The cross rows of epidermal scutes also equal the ribs in number, but they do not follow the direction taken by the gastralia, as they do approximately in Sphenodon. In snakes the rows of epidermal scales equal the ribs. In general, a study of the scales of reptiles would, I think, show that originally, at least, there has been some simple numerical ratio between the segments of the body and the number of gastralia and epidermal scales.

Gastralia of the form described have occurred not rarely in the vertebrates of past ages. They occurred in Archegosaurus and other genera among the Stegocephali, and in the Ichthyosauria, the Sauropterygia, and the Pterosauria among the extinct reptiles. Being so widely distributed among the early reptiles, some of the latter showing relationships in some respects with turtles, it is very probable that the ancestors of the latter possessed similar gastralia. Whether there were several of these for each pair of ribs, as was the case with the Stegocephali, or two, as in Sphenodon, or one, as in Ichthyosaurus, we cannot tell.

Assuming that the plastron of turtles has had its origin in such gastralia, it would be interesting to know how many of these have been concerned in its construction. From the great length of the plastron in most turtles, and the slender form of the gastralia, we might at first suppose that many were involved; but this, I think, would be an erroneous conclusion. We must recollect that turtles possess only ten dorsal and no lumbar vertebræ. Hence not more gastralia can be included than those corresponding to ten pairs of ribs; indeed, not so many.

The umbilicus in young turtles is placed where the suture between the hyoplastra and hypoplastra crosses the mid-line; hence this suture is an approximately fixed line. It corresponds pretty closely to the suture between the fourth and the fifth ribs. Therefore, four pairs of ribs belong in front of it; six pairs behind it. Of the four pairs in front of these sutures, we must, it seems likely, concede that at least two originally were connected with the sternum below, and hence would not

have corresponding gastralia. There could then not have been more gastralia than would correspond to two pairs of ribs. Excluding the entoplastron and epiplastra, which originated otherwise, we have in front of the umbilicus, in most turtles, a single pair of plastral elements, the hyoplastra. But it is evident that in the earliest turtles there was an additional pair, the mesoplastrals. They are present in some living Pleurodira. In the genus Sternothærus[1] the mesoplastrals extend right across the plastron, and meet in the mid-line. In Pelomedusa[2] and Podocnemis[3] they are reduced to the condition of wedge-shaped plates lying on the bridge. In all the Cryptodira and the Trionychia these plates have been extirpated. If, then, we have not assigned too many pairs of ribs to the sternal region, there was originally involved in the preumbilical region the gastralia belonging to only two pairs of ribs, those of a pair of ribs for each pair of plastral elements.

It is possible that six sets of gastralia entered into the composition of the hypoplastra and xiphiplastra. However, we do not find, in Sphenodon or any other forms, that the pubic region is covered with gastralia. In Sphenodon there are three lumbar vertebræ, and some of the hindermost gastralia are much reduced in extent. If the plastron of most turtles extends beneath the pelvic region and even behind it, this is due doubtless to secondary modifications. The condition of the plastron of the Chelydridæ is probably more primitive. We must therefore believe that some of the hindermost gastralia become aborted. I am inclined to the opinion that we have at present in the hinder portion of the plastron elements representing only two pairs of ribs. If the hyoplastra and the mesoplastra each were developed from the gastralia belonging to a single pair of ribs, the same thing appears probable in the case of the hinder plastral elements. Otherwise we must assume that there has been coössification of originally distinct bones ; but the manner in which the mesoplastra have been thrust out of the plastron in most turtles indicates that here

[1] Boulenger. *Cat. of Chelonians*, p. 193, Fig. 47.

[2] *Op. cit.*, p. 199, Fig. 49.

[3] *Op. cit.*, p. 201, Fig. 51.

there is not much tendency toward coössification. This view is borne out by the suppression of the entoplastron in Dermochelys and the Cinosternidæ. For the same reason, and because the Ichthyosauria and the Plesiosauria seem to have possessed only one set of gastralia for each pair of ribs, I am inclined to believe that such was the condition in turtles. It appears that from the Stegocephali upward there has been a tendency toward a reduction in the number of sets of gastralia belonging to each body segment. If later on in the history of turtles certain plastral elements were excluded from the hinder portion of the plastron, as the mesoplastra have in most turtles been excluded, we have no record of the fact. If, then, our surmises are correct, the plastron of most of our turtles consists of the interclavicle, the clavicles, and elements derived from the gastralia corresponding to three pairs of ribs.

In turtles, it will be recalled, the plastral elements of the right and left sides are always distinct. In all for a varying period of life there is in the centre of the plastron a large fontanelle. In some, as Chelydra and the sea turtles, the fontanelle persists through life, or at least until a late period. We are safe in assuming that its existence is a primitive condition. On the other hand, in Sphenodon and in many of the extinct reptiles which possess gastralia, the median element is continuous across the mid-line of the abdomen. It seems therefore probable that the plastral bones of turtles, except clavicles and interclavicle, have been derived from the lateral elements of the primitive gastralia, while the median element has become aborted. I do not overlook the fact that in the crocodiles two distinct bones represent the median element found in the gastralia of Sphenodon. Even in the crocodiles, however, these bones are smaller than are those which lie farther from the mid-line.

U. S. NAT. MUSEUM,
October 10, 1898.

EDITORIALS.

The Editor-in-Chief. — We regret to announce that the present editor-in-chief finds it impossible to continue to devote to the *American Naturalist* the large amount of time that is required for its management, and that he feels compelled to relinquish his charge of the magazine with the issue of the current number.

We are very fortunate, however, in being able to find a successor who may be depended upon to do all that is possible to maintain the value of the *Naturalist* and make it interesting to its readers. One of our associate editors finds it necessary to withdraw on account of pressure of other work, but no further changes in the personnel are expected, and our aims and general policy will remain unchanged.

An Editor Found. — *Natural Science*, now in its thirteenth volume, has been most successful in filling a position in England similar to that which the *American Naturalist* has attempted to fill in this country. It was, in fact, the success of that review which inspired us with the hope that we might attain to a like high standard of excellence. It was with great regret, therefore, that we noted in the October number of *Natural Science* an announcement that the editor who has conducted the journal with so much ability is obliged to discontinue this work on account of increased responsibilities and lack of time. But what was still more to be regretted was that there appeared to be danger that the magazine might cease publication altogether for want of an editor.

We are very glad, indeed, to learn that this danger is now past, and that *Natural Science* will continue to appear as heretofore, arrangements having been made to transfer the journal to an editor who will conduct it on the present plan that has been found to be so satisfactory. We wish him great success.

Artificial Protoplasm. — During the past summer, Professor Alfonso L. Herrera, of the Museo Nacional, Mexico, very kindly sent us some "synthetic protoplasm" which he had prepared, as he says, from some of the substances which are to be found among the components of the myxomycete, *Fuligo septica*, *viz.*: pepsine, peptone, "fibrine acétique," oleic acid, soap, sugar, extract of bile, carbonates

of potassium, of calcium, and of ammonium, lactate of calcium, phosphates of calcium and of magnesium, sulphates of calcium and of iron, and chloride of sodium. When water and tartaric acid were added to this mixture, as directed, and the whole examined under the microscope, a very interesting and often complex series of currents were seen, both on the surface and within the mass. The currents would stream past one another in opposite directions, often reverse, and flow in new directions, and particles of the mingled substances in the soapy mass were often borne along in the current. This would continue from fifteen minutes to half an hour. But these movements were of the more fluid mixture of water and the soluble ingredients, and not of the substance of the mass. No protrusions of the nature of pseudopodia were seen, nor was there anything in the structure or activities of this substance that is truly characteristic of really living protoplasm. Professor Herrera states in his letter, however, that on one occasion when observing a drop of the "synthetic protoplasm" floating upon oil, he saw the production of a pseudopodium-like structure with a clear peripheral layer.

He also calls attention to the fact that oxygen is necessary for the vital processes, and suggests the interesting hypothesis that as the currents in the synthetic protoplasm are kept up by the liberation of carbon dioxide, the protoplasmic movements observed in animals and plants may be due to a similar process. This may be a suggestion in the right direction, but we think most naturalists will agree that this cannot go very far toward explaining the extremely complex activities of the living substance.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Human Remains from Maya Territory.—A few broken calvaria, a few fragments of long bones, and a few sets of teeth are all the skeletal remains that we possess of the ancient inhabitants of the Maya territory. In the admirable report upon the ruins of Copan, by Maudsley, we read that "traces of bones were found," "a few small fragments of human bones were found," etc. The more recent explorations at the same ruin by the expeditions from the Peabody Museum have resulted in the discovery of "fragments" and "filed teeth." The few crania which, it might be inferred from the field notes, were well preserved and which are now in the Peabody Museum are in too fragmentary a condition to be available for study. In his account of the ruins of Xkichmook,[1] Mr. Edward Thompson describes the structure and architectural remains of an interesting group of ruins. We may readily believe that the "Palace," which he pictures in word, photograph, and plan, is "a most imposing structure," as its walls stand 64 feet high and are raised 80 feet above the surrounding level. Notwithstanding the probably dense population, as indicated by the extent of the ruins which formerly occupied the region, very few human remains were found. "Badly decayed human bones and teeth," "fragments of human bones much decayed," etc., is the record of the explorations among the burial chambers.

In a pleasantly written narrative[2] Mr. Gordon gives an account of the Honduras of to-day and of the vast quantities of potsherds and other artifacts that exist along the Uloa River. Whether or not they were manufactured by a race distinct from the Mayas, as suggested by Mr. Gordon and Professor Putnam in his editorial note, they indicate the presence of an extensive population in that valley in former times. However, the disappointing statement again appears, "The human remains . . . consist of crumbling fragments of bone . . .

[1] Thompson, Edward. Ruins of Xkichmook. Field Columbian Museum, *Anthropological Series*, vol. ii, No. 3.

[2] Gordon, George B. Researches in the Uloa Valley, Caverns of Copan, Honduras, *Memoirs of the Peabody Museum of American Archæology and Ethnology*. Cambridge, Mass. Vol. i (1898), Nos. 4 and 5.

too minute to supply any information respecting the form of the burials," or, what is much more important, the character of the skeletons themselves, from which the racial affinities of the people might perhaps be determined. Scarcely second in interest to the long-sought "Rosetta stone of the Mayas" would be a moderately large series of Maya skeletons in a fair state of preservation.

FRANK RUSSELL.

GENERAL BIOLOGY.

Variation in Seedlings. — Professor Herbert L. Jones[1] found in Cambridge, Mass., a sycamore maple, *Acer pseudoplanatus*, which produces seedlings showing a large number of abnormalities. The cotyledons show a tendency to be doubled, and all grades of doubling were found from a mere notch at the distal end of one cotyledon to four complete seed-leaves. Where one cotyledon is completely doubled, the plumule usually consists of a whorl of three leaves, but where there are four complete cotyledons there are never more than two leaves — a very curious correlation. R. P. B.

Chemical Analysis of the Plankton. — The chemical composition of the plankton of the Baltic Sea is discussed and compared with the analysis of certain agricultural products in a recent paper by Brandt.[2] The Copepoda, Peridinidæ, and. diatoms are the predominant forms in the plankton of this body of water. Fifty cubic centimeters of plankton of mixed constitution weigh, when dried, from 1.08 to 1.74 grams; when diatoms predominate, the weight falls as low as .04 gram; and when Copepoda are abundant, it may rise as high as 2.1 grams. The results of the enumerations made of the organisms in the different catches subjected to analysis are utilized in the computation of their number in a gram of the dried plankton. It has thus been determined that it takes 675,000,000 diatoms (principally Chætoceros) or 42,000,000 to 65,000,000 Peridinidæ to weigh one gram; in the case of the marine Copepoda, from 300,000 to 500,000 are required; while the single analysis of a fresh-water plankton composed mainly of the larger individuals indicates that 50,000 to 124,000 are

[1] Jones, H. L. Unusual Forms of Maple Seedlings. Oberlin College, *Laboratory Bulletin* (1898), No. 9.

[2] Brandt, K. Beiträge zur Kenntniss der chemischen Zusammensetzung des Planktons. *Wissensch. Meeresuntersuchungen*, Neue Folge, Bd. iii (1898), Heft 2, pp. 45–90.

sufficient. It is further estimated that on the basis of total dry weight 1 copepod = 135 Peridinidæ = 1687 diatoms; when, however, only the ash-free matter is made the basis of comparison, 1 copepod = 127 Peridinidæ = 4407 diatoms. As the result of the analysis of 15 different catches, the chemical composition of the Copepoda, Peridinidæ, and of the diatoms was ascertained to be as follows, the amounts of the constituent substances being expressed in parts per hundred of the total dry weight.

	Albumen.	Chitin.	Fat.	Carbo-hydrates.	Ash.
Copepoda . . .	59.00	4.70	7.00	20.00	9.30
Peridinidæ . . .	13.00	—	1.40	80.60[1]	5.00
Diatoms[2] . . .	10.75	—	2.50	21.50	65.25[3]

The autumn and winter planktons of the Baltic are quite similar in their chemical composition, which is about midway between that of "rich pasturage" and green lupines, as shown in the following table.

Per Cent Dry Weight.	Albumen.	Fat.	Carbo-hydrates.	Ash.
Rich pasturage . . .	20.6	4.5	64.6	10.1
Autumn plankton . .	20.2–21.8	2.1–3.2	60.–68.9	8.5–15.7
Green lupines	20.6	2.6	72.	4.6

An October plankton, rich in Peridinidæ, principally Ceratium, differs materially from all land products used as fodder, in the small content of fat and the relatively large amount of carbohydrates (cellulose principally). Its nearest chemical counterparts among the products of the soil are to be found in rye straw and meadow hay.

Per Cent Dry Weight.	Albumen.	Fat.	N-Free Extract.	Cellulose.	Ash.
Rye straw . . .	3.5	1.5	38.8	51.3	4.7
Ceratium plankton	13.0	1.3	39.0	41.5	5.2
Meadow hay . .	13.6	3.2	48.2	26.8	8.2

[1] About 50 per cent of this is cellulose.

[2] Principally Chætoceros.

[3] About 50 per cent of this is SiO_2.

The spring plankton is characterized by the predominance of diatoms and a great increase in the amount of ash, which precludes any direct comparison with land plants. If, however, the comparison be based upon the ash-free substance of the diatoms, it is found that this differs from the richer food plants only in the greater proportion of fat, as the following table shows.

Per Cent Dry Weight.	Albumen.	Fat.	Carbo-hydrates.
Lupine — extra quality	29.3	2.8	67.8
Peas (kernels)	27.2	2.3	70.4
Diatoms	28.7	8.0	63.2

The summer plankton is predominantly animal, and thus presents a large amount of albumen, a fat-content at times low, at times abnormally high, and a relatively very small amount of carbohydrates. In these particulars its analysis resembles those of fish, mussels, and other marine animals.

C. A. K.

ZOOLOGY.

Morphology of Trematodes. — An interesting contribution to trematode morphology is contained in the recent paper by Pratt in the *Zoologische Jahrbücher*.[1] An investigation of *Apoblema appendiculatum* has brought to light a condition of the body covering which throws light upon the unsettled question concerning the nature of the outer layer of the body, or "cuticula," in trematodes and cestodes. Five principal views have been advanced concerning the nature of this layer. The older view of Schneider ('73) and Minot ('77) was that the layer is a basement membrane from which the overlying epithelium has been lost. Ziegler ('83) made the suggestion that the cuticula is to be regarded as an epithelium in which the nuclei, cell boundaries, etc., have become obliterated, a view which has attained considerable acceptance from the support given it in recent years by the writings of Braun and Monticelli. Brandes ('92) advanced the view that the layer arises as a secretion of the submuscular cells

[1] Pratt, H. S. A Contribution to the Life-History and Anatomy of the Appendiculate Distomes, *Zoologische Jahrbücher*, Abth. f. Anat., Bd. xi (1898).

which he considered to be glandular in function. Looss ('93) argued that the cuticular layer arises by the migration to the surface of the body of a material set free in the vacuolization of the parenchyma cells. These he believed to be derived from the layer of submuscular cells, which he compared to a Cambrian layer in plants. A fifth view was put forward by Blochmann ('96). According to his ingenious explanation, the outer body covering is a true cuticula secreted by a layer of epithelial cells which have elongated backward and come to lie beneath the layers of muscle fibres. They are more or less separated from one another and connected with the cuticula only by narrow processes extending between the muscle fibres and comparable with the ducts of gland cells.

Apoblema is an appendiculate trematode, and it is upon the cuticular layer covering the caudal appendix that the observations of special interest were made. In the earlier part of its life, passed within the body of a copepod, the caudal appendix is present only in the form of an invagination of the posterior end of the worm forming the caudal vesicle. Later, when the animal becomes free living, the caudal vesicle becomes everted to form the caudal appendix. After this has taken place there is no difference to be observed between the cuticular covering of the appendix and that of other parts of the body. It is a typical trematode cuticula destitute of spines and divisible into two layers, an outer and a deeper one, as shown by differences in reäction toward stains. Immediately beneath the cuticula are the usual layers of muscle fibres, circular and longitudinal, and the layer of submuscular cells. In the appendix, however, the latter layer is absent.

In the condition when the appendix is invaginated to form the caudal vesicle its cuticular layer is covered externally (toward the lumen of the vesicle) by a layer of columnar epithelial cells, over which is a delicate membrane — a true cuticula. In other words, in the caudal vesicle the layer which is later to become the cuticular covering of the appendix has precisely the relations of a basement membrane. About the time that the vesicle becomes evaginated to form the appendix, the layer of epithelial cells separates from the cuticular layer upon which it rests. Evidence for this, Pratt found in the presence of shriveled epithelium in the caudal vesicle nearly separated from the underlying cuticula.

This evidence from Apoblema furnishes strong support for the older theory that the body covering represents what was primarily a basement membrane. Pratt takes this view, but argues that the layer

has been modified and thickened by the addition to it of connective-tissue material from the deeper lying parenchyma. That the submuscular cells do not secrete this material is shown by the fact that the submuscular layer is absent from the caudal appendix of Apoblema, though the cuticular layer is as well developed there as over other parts of the body. It will be seen that the view which Pratt advocates is essentially the theory of Looss grafted upon the older view of Schneider and Minot. The evidence which he brings forward strongly antagonizes the views of Ziegler, Brandes, and Blochmann.

Pratt's account of the life-history of Apoblema differs from that given by previous investigators. He believes that the copepod is the primary host within which the young worm lives until it is nearly mature. It then escapes from the body of the copepod by forcing its way outward between two thoracic segments — a process which the author observed repeatedly. The young worm, while swimming about freely in the water, is probably swallowed by some fish, which thus becomes its final host.

W. S. NICKERSON.

Michigan Unionidæ.[1] — The distribution of the Unionidæ of Michigan has been worked out by Mr. Bryant Walker from a census which the Conchological Section of the Michigan Academy of Science has taken of all the known public and private collections within that state. Michigan possesses the richest unione fauna of all the territory tributary to the Great Lakes, and, as the state is wholly within the St. Lawrence basin, the problem is not complicated by the political boundaries of the investigation. Sixty-one species belonging to the genera Unio, Margaritina, and Anodonta are recognized. Of these only a small number have a general distribution; a few are peculiar to the northern part of the state; and several are confined to Lake Erie and the waters immediately tributary to it. On the other hand, a great majority of the total number (75 per cent of the species of Unio and Margaritina) are confined to the Grand-Saginaw valley and the region to the south of it. These forms are members of the fauna of the Mississippi basin, while those of the southeastern part of the state show decided affinities to the Ohian fauna. But two species peculiar to the fauna of the Atlantic region are found, and these have a general distribution throughout the state. Their westward migration could have taken place readily along existing waterways. On the other hand, the explanation of

[1] Walker, Bryant. *The Distribution of the Unionidæ in Michigan.* Detroit, 1898. Printed for the author. 20 pp., 3 pls.

the very large immigration of forms from the Mississippi and Ohio valleys is found by the author in the topographical changes incident to the glacial period. The formation of the Des Plaines and Maumee outlets to the lake region, as the ice-sheet receded, established the channels along which the Unionidæ of the Mississippi and the Ohio entered the Michigan area. The opening of the Grand-Saginaw valley as an outlet for the glacial lake Maumee into Lake Michigan, and the subsequent closing of the Maumee outlet, afforded the opportunity for the Unionidæ of the Mississippi to invade this region. It is a significant fact that the present range of the most of the invading species is still confined within the beach lines of the glacial lakes.

C. A. K.

The Plankton of Puget Sound.[1] — As the result of the examination of a vertical series of catches, taken at five levels in a depression in Puget Sound 112 fathoms in depth, the conclusion is reached that the surface strata present the greatest number of living individuals and furnish the most favorable, though irregular, conditions for their multiplication. The relative number of living and dead individuals changes in going from surface to bottom; for example, 82 per cent of Coscinodiscus in the surface water were alive, but only 29 per cent in the bottom water. A great accumulation of this genus in the deeper water is explained as the probable result of a previous, but no longer continuing, period of rapid growth in the surface water, followed by subsidence to the deeper strata. In the case of some diatoms the conditions of growth seem to be well fulfilled in the lower strata. Indeed, all the organisms of the plankton were found in a living condition throughout the 112 fathoms, excepting the Copepoda, which were not met with below 64 fathoms.

C. A. K.

Faune de France.[2] — This is the third volume issued of one of those convenient manuals of systematic biology so frequent in the Old World and so rare in the New. Would that we had something of the sort for other groups than vertebrates! The first volume of this *Fauna of France* dealt with the Coleoptera; the second embraced the rest of the Hexapoda. This volume contains the other Invertebrata, including the Thysanura, which were omitted from Vol. ii.

[1] Peck, J. I., and Harrington, N. R. Observations on the Plankton of Puget Sound, *Trans. N. Y. Acad. Sci.*, vol. xvi, pp. 378–387, Pls. XXXVII, XXXVIII.

[2] *Faune de France*, par A. Acloque, tome iii, 500 pp., 1664 figs., 18 mo. Paris, 1899. 10 frcs.

This work differs from the familiar *Leunis* in that it is a descriptive catalogue, incomplete in some of the smaller or more difficult forms, of all the animals within a certain geographical territory, with analytical keys of families, genera, and, in most cases, of species as well. The illustrations (process cuts), though small, are in most cases characteristic. While intended for France, American students will frequently find this volume of value because of the similarity of genera in many instances on the two continents and their seas. K.

Fishes New to New England. — In *Science*, No. 199, Mr. Hugh M. Smith gives notes on a number of fishes, mostly tropical in their general range, which have been taken in recent years at or near Woods Holl, Mass. The list includes the following species: *Germo alalunga*, the long-finned albacore; *Chætodon ocellatus*, the parche; *C. striatus*, the Portuguese butterfly; and a new species, *C. bricei; Neomenis aya*, the red snapper; *N. apodus*, the schoolmaster; *N. analis*, the mutton fish; *N. griseus*, the mangrove snapper; *N. jocu*, the dog snapper; *Canthidermis asperrimus*, a trigger fish; *Diodon hystrix*, porcupine fish; *Athlennes hians*, a marine gar; *Trachinotus goodei*, the black-finned pompano; two species of half-beaks, *Hemirhamphus braziliensis* and *Hyporhamphus roberte;* and a small file fish, *Alutera*, apparently new. There have now been reported from Woods Holl 222 species of fish — a larger number than from any other locality in the United States with the single exception of Key West.

Systematic Position of the Pycnogonids. — Ihle comes to the rather startling conclusions[1] that these forms must be regarded as tracheates which have lost their trachea and which are direct discordants of primitive myriapods. They have no near relationship with arachnids or crustaceans, and the few features in which they resemble these must be regarded as the results of convergence. They have so far departed from the myriapod stock that they must be regarded as a distinct class of tracheates.

Crustacea of the Northrop Collection.[2] — Dr. Rankin has published a list of the crustacea collected by Professor and Mrs. Northrop in the Bahamas during the year 1890. Most of the species are mentioned merely by name, with references to the original descriptions. Four new species and one new variety are

[1] *Biolog. Centralblatt*, Bd. xviii (1898), p. 603.

[2] Rankin, W. M. The Northrop Collection of Crustacea from the Bahamas, *Annals N. Y. Acad. Sci.*, vol. xi (1898), No. 12.

described and figured, *viz.: Stenopus scutellatus, Leander northropi, Alpheus hippothoë* de Man, var. *bahamensis, Alpheus nigro-spinatus,* and *Athanas ortmanni.* Descriptions are given also of *Uca leptodactyla* Guerin MS., *Stenopus hispidus* Latreille, and *S. semilævis* von Martens, and the two species of Stenopus are figured. The common Gonodactylus of the West Indies is mentioned under the name *G. œstedii* Hansen, although the difference between this form and *G. chiragra* Fabr. of the East Indies is very slight. R. P. B.

BOTANY.

A Monograph of the Genus Caulerpa.[1] — There is hardly any group of algæ so fascinating as the genus Caulerpa, though there is hardly any genus, certainly none among algæ of the same size, concerning which the known facts, except as to external form, are so few. A genus so distinctly marked that there is no question whatever as to its limits; containing from fifty to one hundred species, according as one takes the broader or the narrower idea of a species; the plants having a beauty, and at the same time a variety almost unrivaled, differentiated into a creeping stolon, sometimes several feet in length, roots going deep into the sand, and erect fronds, often very richly branched; and yet the whole plant consisting of a single cell. Abundant in all tropical and subtropical waters, an object of study by botanists for over fifty years, we are to-day absolutely ignorant of any form of reproduction other than by a portion of a frond breaking off and maintaining an independent existence and growth.

Not the least curious character of the Caulerpæ is the manner in which the erect fronds mimic the various higher plants. A list of the names of the twelve sections of the genus gives some idea of this; they are Vaucherioideæ, Charoidæ, Bryoideæ, Zosteroideæ, Phyllantoideæ, Filicoideæ, Hippuroideæ, Lycopodioideæ, Thuyoideæ, Araucarioideæ, Paspaloideæ, and Sedoideæ; and in the specific names this is carried still further, as in *C. taxifolia, C. selago, C. ericifolia, C. cactoides,* etc.

As usual in large genera, there is likely to be considerable difference of opinion as to the limits of species, especially when, as in this

[1] Monographie des Caulerpes, par Mme. A. Weber-Van Bosse. *Annales du Jardin Botanique de Buitenzorg,* tome xv, pp. 243–401, Pls. XX–XXIV.

case, very few of the species have been seen by their authors except as dried specimens; any one who has given any attention to the genus must recognize the difficulty of distinguishing many of the described species. With the intention of doing what was possible towards clearing up the subject, Mme. Weber-Van Bosse has made it a special study for several years, and the result is the paper just published in the *Annales du Jardin Botanique de Buitenzorg.*

Two long voyages to the tropics, specially for the observation of the living plants, and a careful study of the specimens in all the great herbaria of Europe, including authentic specimens of practically all described species, have placed the author in a position to carry out the work in a way heretofore impossible; and the paper which is the result of her studies leaves apparently little to be done in the way of classification and general arrangement of the genus. The grouping is practically the same as in Agardh's memoir of 1872; but the specific limits change considerably; varieties and forms in several cases representing what were before considered good species. Agardh's paper gave sixty-four species; De Toni's *Sylloge*, 1889, seventy-four, not including doubtful species; Mme. Weber describes five new species, but, including these, her list is only fifty-four. Any one who has struggled to distinguish the Florida and West Indian *C. juniperoides*, *C. cupressoides*, *C. ericifolia*, etc., not from a single specimen of each, but from a lot of some hundreds, will appreciate the justice of a classification which unites under *C. cupresoides* these and four more of the older species.

In the matter of nomenclature a number of changes have been made, usually to substitute an older specific name for the one commonly received; though in one or two cases, where this would result in the substitution of an obscure and also inappropriate name for a universally known and appropriate one, the change has not been made. The introductory chapter contains a full account of previous studies on the structure and growth of Caulerpa; the plates are excellent; the descriptions full; and the synonymy very complete, so much so that the absence of any index is a matter for regret.

As to the question of fructification, there are only a few tantalizing hints: in two instances, each in a different species, an arrangement of the protoplasm similar to that which precedes the formation of spores in certain genera of green algæ; the fact of the disappearance of certain species during certain months, and their regular reappearance; and one or two other indications pointing to the probability of growth from spores; these are all that we can learn. But the author

is planning another voyage to the Malay Archipelago for the express purpose of studying the question of fructification, and we may hope that it then will be settled.

A New Volume of De Toni's Sylloge. — The *Sylloge Algarum*,[1] by J. B. De Toni, begun in 1889, has now reached Vol. iv, of which the first section is just issued. This volume will contain the Florideæ, arranged on the Schmitz-Hauptfleisch system, as given in Engler and Prantl. A work like the *Sylloge*, giving a more or less complete diagnosis, in its appropriate systematic place, of every published species of alga, with references not only to the original publication but also to all the important works in which the species is mentioned, saves an immense amount of time otherwise needed in looking over the very scattered literature of the algæ. It should not be forgotten, however, that the *Sylloge* is not intended to be a critical revision, and any attempt to determine species of a large or difficult genus by it would give very uncertain results. In a work of this extent, so largely references, some omissions and errors are probably unavoidable, and it is hardly safe to copy any reference without verification; but perhaps this is the only safe rule, even with the most accurate works.

Studies on Phytoplankton. — The study of the plankton, the minute animal and vegetable life distributed through the sea, at all depths, has attracted much interest recently and seems likely to have important practical results. Recent publications, by Cleve[2] and others, indicate that the pelagic flora and fauna of each great region has a character of its own, and that by observing the changing character at any given locality it may be possible to ascertain from what oceanic region the currents are flowing at the time. At certain points on the coast of Sweden, for instance, the water at one time of the year shows the characteristics of the southern part of the German ocean; at another part of the year, the characters of the Arctic and North Atlantic. That a more thorough knowledge of the laws governing these changes may give some indication of the causes of the migrations of food fishes seems not improbable; the practical value of such knowledge would be very great.

[1] De Toni, J. B. *Sylloge Algarum hucusque cognitarum*, vol. iv, Florideæ, Sectio 1, Familiæ I–IX. Patavii, 1897.

[2] Cleve, P. T. A Treatise on the Phytoplankton of the Atlantic and its Tributaries, and on the Periodical Changes of the Plankton of Skagerak. Upsala, 1897.

Cleve, P. T. Karaktäristik af Atlantiska Ocean vatten pa grund af dess mikroorganismer. Oefvers. K. Vetensk. Akad. Forhandl., Stockholm, 1897.

The Cryptogams of the River Elbe. — An interesting subject is treated by Dr. B. Schorler,[1] in his paper on the cryptogams of the river Elbe, and their effect on the impurities which the river receives from the city of Dresden. The subject is certainly not a threadbare one, and it is considered with German thoroughness; it seems probable that in many cases the relatively low algæ and the non-chlorophyllaceous Schizophytes may have a decided influence on the self-purifying of contaminated waters.

F. S. C.

Rockery and Aquarium Plants. — Attractively gotten-up handbooks for the amateur gardener, who wishes to diversify his collection, are Wocke's *Alpen-Pflanzen*[2] and Mönkemeyer's *Sumpf- und Wasserpflanzen*.[3] Both are pleasantly written and well illustrated. If a comparison were to be made between them, the first-named would be characterized as the better done.

T.

Nomenclature in Horticulture. — Prof. F. A. Waugh, in a little brochure recently issued,[4] calls attention to the need of general adoption of a consistent system of nomenclature for plants cultivated by the gardener and orchardist. His meaning is made clear by the citation in full of several examples of correct nomenclature and synonymic citation, taken from recent publications on fruits and garden vegetables.

T.

Botanical Notes. — "The Red Desert of Wyoming and its Forage Resources" is the title of a bulletin by Prof. Aven Nelson, recently published by the Division of Agrostology of the U. S. Department of Agriculture. The paper is illustrated by several reproductions of photographs showing the character of the desert growth, and by a number of figures of grasses and other plants.

Under the title "Studies in the Herbarium and the Field, No. 2," Miss Alice Eastwood, the active curator of the herbarium of the Cal-

[1] Schorler, A. Gutachten über die Vegetation der Elbe und ihre Bedeutung für die Selbstreinigung derselben. Dresden, 1897.

[2] Wocke, Erich. *Die Alpen-Pflanzen in der Garten-Kultur der Tiefländer.* Ein Leitfaden für Gärtner und Gartenfreunde. Berlin, Gustav Schmidt, 1898. 8vo, xii + 257 pp.

[3] Mönkemeyer, Wilh. *Die Sumpf- und Wasserpflanzen.* Ihre Beschreibung, Kultur und Verwendung. Berlin, Gustav Schmidt, 1897. 8vo, iv + 189 pp., ff. 126.

[4] Waugh, F. A. *Notes on Horticultural Nomenclature.* New York, American Gardening, 1898. 26 pp.

ifornia Academy of Sciences, publishes a series of articles on The plants of San Nicolas Island; New species of Cnicus from southern Colorado and Utah; The Colorado alpine species of Synthyris; The manzanitas of Mt. Tamalpais; Two species of Eriodictyon, heretofore included under *E. tomentosum;* and New species of Pacific Coast plants. Four excellent detail plates add to the value of the paper, which is brought out as No. 3 of the current botanical volume of the *Proceedings of the California Academy of Sciences.*

Mrs. Alice Carter Cooke, who, with her husband, has passed a considerable time in the Canary Islands, publishes popular articles on their flora in the *Bulletin of the Torrey Botanical Club* for July and the *Popular Science Monthly* for October. The last-mentioned article is attractively illustrated.

An address given by Professor Miall before the Royal Institution last February, on "A Yorkshire Moor," is published in *Nature*, Nos. 1503–4. It contains an ecological account of the principal moor-plants, and is illustrated by a number of habit and histological figures, which aid in rendering intelligible the modifications from normal structure by which these plants are adapted to their peculiar mode of life.

The genus Nigella is revised by Terracciano in a paper[1] reprinted from the *Bollettino del R. Orto Botanico di Palermo*, Vol. i, Nos. 3 and 4, and Vol. ii, No. 1.

An account of the Capparidaceous genus Boscia, to which is appended an analytical key to the species, based on leaf anatomy, is concluded in the *Bulletin de l'Herbier Boissier* of September 14. The paper is to be illustrated by fourteen plates, the publication of which, however, has been deferred until the next number of the *Bulletin.*

The extra-nuptial nectaries of Bombaceæ form the subject of an elaborate memoir by Dr. Achille Terracciano in the second fascicle of the current volume of *Contribuzioni alla biologia vegetale*, a publication of the Botanic Institute of Palermo. Several plates contain figures showing the distribution and structure of the organs.

Gillenia trifoliata, the Indian physic, is written of and figured in the *American Journal of Pharmacy* for October, in which is also contained the first of a series of tables for the qualitative examination of powdered vegetable drugs, by Henry Kraemer.

[1] Terracciano, Achille. *Revisione monografica delle specie del genere Nigella.* Palermo, 1897–8. 8vo, 62 pp.

Rosa stellata, a New Mexican relative of the Lower Californian *R. minutifolia*, which was described by Professor Wootton in the *Bulletin of the Torrey Botanical Club* of March last, is made the subject of a critical note by the eminent rhodologist Crépin, in the *Bulletin de l'Herbier Boissier* for September.

Rubber forms the subject of Pt. 8 of Vol. iii of the *Bulletin of Miscellaneous Information* of the Trinidad Botanic Gardens.

A paper by Blanc and Decrock, on the geographical distribution of the Primulaceæ, is brought to conclusion in the September number of the *Bulletin de l'Herbier Boissier.*

In Nos. 49–51 of *Die Gartenwelt*, Alwin Berger, curator of the acclimatization garden at La Mortola, on the Riviera, briefly describes the more common and attractive of the cultivated Agaves, illustrating his paper by half-tone reproductions of excellent photographs of a considerable number of species, which show these as they are grown in the open air at La Mortola.

The variability of the Norway spruce, *Picea excelsa*, is discussed at some length in a well-illustrated paper by C. Schröter, published in the August number of the *Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich.*

D. T. Johnson publishes a paper on the leaf and sporocarp of Pilularia in the *Botanical Gazette* for July, and a paper on the development of the leaf and sporocarp in *Marsilia quadrifolia*, in the *Annals of Botany* for June.

Laboratory Bulletin, No. 9, of Oberlin College, issued in June, is entirely devoted to botanical subjects: The effects of bloom on the transpiration of leaves, by Roberta Reynolds; A new species of Pyrenomycete parasitic on an alga; List of Ohio plants not recorded in the latest state catalogue; and Unusual forms of maple seedlings, — the last three by the late Professor Herbert L. Jones.

The *Proceedings of the Indiana Academy of Science* for 1897 contains the following botanical articles: Golden, Pure yeast in bread; Stone, The susceptibility of different starches to digestive ferments; Bryan, Evolution of free nitrogen in bacterial fermentations; Ferris, Micro-organisms in flour; Bitting, The number of micro-organisms in air, water, and milk, as determined by their growth upon different media; Thomas, The effect of formalin on germinating seeds; Olive, A list of the Mycetozoa, collected near Crawfordsville; Snyder, The germ of pear blight; Arthur, Water power for botanical apparatus; Coul-

ter, Contributions to the flora of Indiana, No. 5, and Experiments in germination of composites; Cunningham, The Ericaceæ of Indiana, and Indiana's Gentianaceæ; Wright, Inarching of trees, and Notes on the cypress swamps of Knox County.

As President of the Michigan Academy of Science, Prof. V. M. Spalding delivered, some months since, an address on *A Natural History Survey of Michigan*, which has been issued in pamphlet form. His plea for the organization of such a survey is timely, and the results being reached in Wisconsin should make success reasonably certain if it were organized in the proper manner.

PETROGRAPHY AND MINERALOGY.

A New Edition of Dana's Mineralogy.[1] — The latest edition of Dana's *Text-Book of Mineralogy* is practically a new book. It is unquestionably the best text-book of modern mineralogy that has appeared. In its general make-up it resembles very closely the earlier editions of the book bearing the same title, but in its contents it varies widely from these. The entire book has been rewritten, and all of its parts have been brought quite up to date.

"In the chapter on crystallography, the different types of crystal forms are described under the now accepted thirty-two groups, classed according to their symmetry. The names given to these groups are based, so far as possible, upon the characteristic form of each, and are intended also to suggest the terms formerly applied in accordance with the principles of hemihedrism. The order adopted is that which alone seems suited to the demands of the elementary student, the special and mathematically simple groups of the isometric system being described first" (from author's preface). The discussion of crystallographic symmetry is remarkably simple. It should be clear to any student.

The section devoted to the explanation of the general principles of optics, and of the optical characters of minerals, is particularly welcome in an English text-book. All of the most important optical principles are expounded, the optical characteristics of the different crystal systems explained, and the methods used in determining their

[1] Dana, E. S. A Text-Book of Mineralogy, with an extended Treatise on Crystallography and Physical Mineralogy. New edition, entirely rewritten and enlarged. New York, John Wiley & Sons, 1898.

values are fully illustrated. This last-mentioned feature of the volume will be enthusiastically received by English-speaking teachers of mineralogy, since it embodies descriptions of methods heretofore available only in foreign text-books.

The descriptive part of the volume is essentially an abridgment of the sixth edition of Dana's *System of Mineralogy.*

Two excellent indices close the book. One is a general index, or index of topics, and the other an index to the mineral species discussed. The two occupy about twenty-two pages.

The volume constitutes an excellent introduction to modern mineralogy. It fills a want long felt by teachers who realize that the study of minerals is much more than a mere *description* of chemical compounds. This has long been understood on the continent of Europe, where the best mineralogical text-books have heretofore been published, and now, we are glad to say, it is being rapidly accepted as a truth in America; a fact due largely to the interest taken by American students in petrographical investigations. Professor Dana's text-book is the equal of any foreign text-book, either as a student's handbook of descriptive mineralogy or as an introduction to special works in petrography.

It is unnecessary to state that the treatment of all branches of the subject is accurate and as full as is desirable, since the author's name is a guarantee that the work is well done.

W. S. B.

Michigan Volcanics. — Clements[1] decribes a series of intrusive rocks from the Crystal Falls iron district in Michigan which he believes to be genetically connected. Embraced in the series are diorites, gabbros, norites, and peridotites. The diorites are intermediate in acidity. They vary in texture between granitic, ophitic, and micropegmatitic. Their plagioclase is andesine, but in addition to this feldspar they contain also considerable quantities of orthoclase. This mineral and quartz form the mesostasis. Brown and green hornblende are both present, the latter surrounding nuclei of the former. Both are regarded as primary. The mineralogical varieties of the rock recognized are: quartz-diorite, tonalite, quartz-mica-diorite, and mica-diorite. By the subordination of the plagioclase and an increase in the proportions of orthoclase and quartz present, the diorites pass into granites.

The gabbros and norites, like the diorites, contain more or less orthoclase and a large quantity of hornblende. This latter mineral

[1] *Journ. of Geol.*, vol. vi (1898), p. 372.

occurs in two varieties, a reddish brown and a dark green one, the latter only as zonal growths around the former. The hornblende-gabbros are occasionally porphyritic through the development in them of phenocrysts of brown hornblende. The peridotites include wehrlite, cortlandtite, and other types that grade into one another and into gabbro. In some of the peridotites the olivines are surrounded by rims of orthorhombic pyroxene, and these by rims of hornblende.

All these various rocks are regarded as belonging to one geological unit, the order of succession of its parts being gabbro, peridotite, and diorite, and, finally, possibly granite.

Analyses: Mica-diorite (I), hornblende-gabbros (II), bronzite-norite (III), and peridotite (IV).

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	H_2O	P_2O_5	CO_2	Total
I.	58.51	.72	16.32	2.11	4.43	3.92	3.73	4.08	3.11	2.23	.30		= 99.46
II.	49.80	.79	19.96	6.32	.49	11.33	7.05	.61	2.22	1.84	.07	.15	= 100.63
III.	48.17	1.00	25.26	1.13	6.10	9.53	4.22	.73	1.34	2.19	.07	.43	= 100.17
IV.	44.99	.97	5.91	3.42	8.30	8.79	21.02	.74	.91	3.82	.05	tr.	= 99.17

The peridotite contains also .25 per cent Cr_2O_3.

California Rocks. — In an article discussing the geology of the coast ranges in California, Turner[1] gives some interesting information concerning the igneous and the metamorphic rocks of the district, and corrects some erroneous notions heretofore held concerning the latter. The metabasalts and diabases were thought by Whitney to be metamorphosed sandstones — a view also held by Becker concerning some of them. These are all igneous rocks of the usual character of altered basalts and diabases. The "fourchite" of Ransome from Angel Island is also a metabasalt (altered basalt). The serpentines, regarded by Whitney and by Becker as altered sandstones, are also shown by Turner to be altered igneous rocks in which olivine, or orthorhombic pyroxene, was an original constituent. The idea that the serpentine is a changed sandstone was due to the fact that some of the sandstones associated with it contain some igneous material, and that this has changed in part to serpentine.

The amphibole-schists and the blue amphibole-schists of the Golden Gate series were looked upon by Ransome and by Lawson as contact metamorphosed rocks. The author urges reasons for believing them to be regionally metamorphose volcanic masses.

Adirondack Gneisses. — Some interesting facts concerning the gneisses associated with the crystalline limestones in St. Lawrence

[1] *Journ. of Geol.*, vol. vi (1898), p. 483.

County, N. Y., are brought out by C. H. Smyth, Jr.,[1] in a recent paper. The term "gneiss" is made to cover all the gneissoid rocks of the district studied, whether they be acid or basic. All the gneisses are not of the same age; some are younger than the limestone with which they are associated. As to origin, it is definitely shown that a large portion of them are igneous. It is also inferred by the author that, "the gneisses constitute a complex series of rocks, differing somewhat in age, and largely, if not wholly, of igneous origin; parts of this series are clearly younger than the limestones, and while other parts may be older than the latter formation, there is nothing as yet to prove that this is the case. An exception to the latter statement is probably afforded by certain laminated gneisses of limited extent, which appear to underlie the limestone, perhaps marking the base of the series."

Notes.—Derby[2] has separated the constituents of the itacolumite of the Minas Geraes district, of Goyaz, and of Bahia, Brazil. The quartz grains show no evidence of clastic origin. The micaceous component is usually some form of muscovite, though occasionally it is some brittle mica. Magnetite, hematite, and pyrite are quite common. Rutile or anatase is frequently met with, and zircon is so abundant that it must be regarded as a concentration in a sediment. It moreover bears evidence of having been transported by water. A few of the specimens contain clastic grains of dark tourmaline that have been secondarily enlarged by the deposition of light-colored tourmaline around the dark nuclei. The result of the study leads the author to conclude that the itacolumite is a metamorphosed sandstone.

A list of dykes found by Cushing[3] in Clinton County, N. Y., is reported in a paper on the geology of Clinton County. The material of the dykes embraces diabase, olivine-diabase, bostonite, fourchite, camptonite, monchiquite, and fourchite.

[1] *Fifteenth Annual Report State Geologist.* Geol. Sur., State of N. Y., 1895, p. 481.

[2] *Amer. Journ. of Sci.*, vol. v (1898), p. 187.

[3] *Fifteenth Annual Report State Geologist.* Geol. Sur., State of N. Y., 1895, p. 503.

SCIENTIFIC NEWS.

THE *Report of the Essex Institute* for the past year is at hand. From it we learn that the society is likely to receive $10,000 by the will of the late George Plumer Smith, of Philadelphia, and an indefinite amount (we learn elsewhere estimated at $50,000) from the estate of the late George L. Ames, of Salem. The total number of additions to the library amount to 7123. The income for the year was $8040, the expenses $7970. The funds of the institute amount to over $100,000. The greatest present need is a stack for its library, which has increased far beyond its accommodations, so that many thousand volumes have had to be packed away.

The expedition recently sent out by Columbia University, with funds provided by Mr. Charles H. Senff, to obtain embryological material of the African mudfish, *Protopterus*, was not successful in its main object. It however brought back a quantity of the adult fish from the Nile and large collections of other material from the eastern Mediterranean and the Red Sea.

Those who have attentively examined the plates illustrating the papers turned out from the zoological laboratories of Harvard University will have noticed the peculiarity of the reference letters upon the figures. They are in all cases abbreviations of the Latin name of the structure and organ in question. At the recent Zoological Congress a committee was appointed consisting of Profs. F. E. Schulze, Paul Pelseneer, E. L. Mark, and Mr. A. H. Evans, who are to report upon the practicability of uniformity in abbreviations and other matters of terminology.

Mr. C. F. Baker, of the Alabama Experiment Station, goes, on Jan. 1, 1899, on a collecting trip to South America. He expects to be gone a year and a half.

John P. Marshall, professor of geology and mineralogy at Tufts College since its foundation, has resigned and has been appointed professor emeritus.

Dr. J. H. Gerould, assistant in zoology in Dartmouth College, will spend this year in Europe.

It has cost Columbia University nearly $7,000,000 to purchase land, erect its buildings, and to move to its new site.

The biological and geological departments of the Massachusetts Institute of Technology have moved into their new quarters in the Pierce Building recently erected. For years they have been in very cramped quarters.

In the *Journal of Applied Microscopy* America at last has a periodical devoted to microscopical technique, etc., worthy of the name. In this connection we notice, without regret, the decease of one of our alleged microscopical journals.

The French Association for the Advancement of Science has funds amounting to $220,000. Its income during the past year was over $20,000, and it granted more than $8000 at its meeting this year for scientific purposes.

As we are about to go to press the sad intelligence reaches us of the death of Dr. James I. Peck, assistant professor of biology in Williams College and assistant director of the Marine Biological Laboratory at Woods Holl.

Recent appointments: Prof. F. Blochmann, of Rostock, professor of zoology in the University of Tübingen. — Dr. L. Bordas, chief of zoological work in the faculty of sciences in Marseilles. — Antonio Borzi, professor of zoology and comparative anatomy in the University of Palermo, as successor to Kleinenberg. — Dr. T. D. A. Cockerell, professor of entomology in the New Mexico Agricultural College. — Dr. Rudolf Disselhorst, professor of animal physiology in the University of Halle. — Dr. A. Fleischmann, professor of zoology in the University of Erlangen. — Dr. C. Fritsch, director of the botanical collections of the University of Vienna. — M. Albert Gaillard, curator of the Lloyd herbarium at Angers, France. — Edwin S. Goodrich, demonstrator of anatomy in the University of Oxford. — Dr. D. Frazer Harris, lecturer in physiology in the University of St. Andrews. — Dr. Ernst Kalkowsky, director of the mineralogical, geological, and archæological collections in Dresden. — Dr. Keller, professor of zoology in the Polytechnicum at Zürich. — Dr. Kerschner, professor of histology in the University of Innsbruck. — Dr. Kolkwitz, privat docent in botany in the University of Berlin. — Alberto Löfgren, director of the botanical gardens at Sao Paulo, Brazil. — Charles P. Lounsbury, of Amherst, Mass., government entomologist at Cape Town, Africa. — Mr. J. H. McGregor, assistant in zoology in Columbian University. — Dr. M. von Minder, assistant in botany in the University of Giessen. — Dr. Mrensbier, professor extraordinarius of

comparative anatomy in the University of Moscow. — Mr. A. H. Phillips, assistant professor of mineralogy in Princeton University.— Dr. Fritz Römer, of Jena, assistant in the zoological museum in Berlin. — Dr. Fritz Schaudinn, privat docent for zoology in the University of Berlin. — Dr. Schröter, privat docent in botany in the University of Bonn. — Dr. O. Seeliger, of Berlin, professor of zoology in the University of Rostock. — Prof. C. H. Tyler Townsend, biogeographer and systematic entomologist to the New Mexico Agricultural Experiment Station. — Dr. Voges, director of the Bacteriological Institute at Buenos Ayres. — Prof. Georg Volkins, custodian of the botanical gardens in Berlin. — Dr. R. Wagner, of Munich, assistant in the Institute for Vegetable Physiology at Heidelberg. — E. O. Wooten, professor of botany in the New Mexico Agricultural College. Dr. Zograf, professor extraordinarius of zoology in the University of Moscow.

Recent deaths: Dr. Axel Blytt, professor of botany at Christiania, aged 54.— Dr. Sven Borgström, bryologist, at Stockholm, May 13, aged 72. — M. Joseph Charles Hippolyte Crosse, the well-known conchologist, at Vernon, France, August 7, aged 71.— Prof. John Comfort Fillmore, ethnologist, of Pomona College, California, August 14, at Taftville, Conn. — Camille Flagey, lichenologist, in Algiers, aged 62. — Prof. L. Glaser, entomologist, in Mannheim, Germany. — Dr. Arnold Graf, cytologist, of New York, in Boston, September 3, after a short illness. — Herbert L. Jones, professor of botany in Oberlin College, August 27, aged 32. — M. J. M. Moniez, naturalist, at Madeira, July 11. — M. Gabriel de Mortillet, the eminent anthropologist of France, aged 77. — Dr. August Pollmann, a prominent student of bees, at Bonn, May 16, aged 85.

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